Ontario

Ministry of Transportation
Materials Engineering and Research Report

Aggregate and Soil Proficiency Sample Testing Program for 2002

MERO-002

Technical Report Documentation Page

Publication Title	**Aggregate and Soil Proficiency Sample Testing**
Author(s)	Mark Vasavithasan, Chris Rogers
Originating Office	Materials Engineering and Research Office, Ontario Ministry of Transportation
Report Number	MERO-002; ISBN 0-7794-4219-9
Publication Date	February, 2003
Ministry Contact	Soils and Aggregates Section, Materials Engineering and Research Office, Ontario Ministry of Transportation, Room 220, Building C, 1201 Wilson Avenue, Downsview, Ontario, Canada M3M 1J8 Tel: (416) 235-3735; Fax: (416) 235-4101

Abstract

The Materials Engineering and Research Office, Soils and Aggregates Section, runs a proficiency sample testing program each year to provide a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating public and private sector laboratories, starting in July. The laboratories report their results starting in the latter part of August. A preliminary report, issued in early November, gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may have occurred. A final report is issued after analysis of the data has been completed.

This is the final report for the Aggregate and Soil Proficiency Samples for 2002. This year there were two hundred and fifteen laboratories participating from the private sector, various municipalities and other provincial governments.

Results of the 2002 Proficiency Sample Program show noticeable improvements compared to previous years' results. Particularly, the results of sieve analyses (coarse), wash pass 75-μm, Los Angeles Abrasion and impact, relative density and absorption, magnesium sulphate soundness (coarse & fine), percent crushed particles, percent flat and elongated particles, one-point proctor and Micro-Deval (coarse) show improvements over previous years'. This is likely due, in part, to laboratory improvements brought about by the Canadian Council of Independent Laboratories (CCIL) inspection program of Aggregate Laboratories. Although there is noticeable improvement in results, strong laboratory biases still remain in a majority of the test procedures. The results of hydrometer and specific gravity of soil tests show marked improvements over previous years'.

This year, we continued with our rating system for laboratories. The rating system has acted as an incentive for laboratories to improve their performance.

Key Words	Aggregate, correlation, laboratory, proficiency testing, soil, testing
Distribution	Unrestricted technical audience.

Ontario

Ministry of Transportation
Materials Engineering and Research Report

MERO-002

Aggregate and Soil Proficiency Sample Testing Program for 2002

February 2003

Mark Vasavithasan and Chris Rogers
Materials Engineering and Research Office
Soils and Aggregates Section
Ontario Ministry of Transportation

1201Wilson Avenue,
Downsview, Ontario, Canada M3M 1J8
Tel: (416) 235-3735; Fax (416) 235-4101

Published without prejudice as to the application of the findings.
Crown copyright reserved.

Table of Contents

Executive Summary iii

1.0 Introduction 1

2.0 Test Results 2

2.1 Table of Test Results 2

2.2 Scatter Diagrams 3

2.3 Outliers 8

3.0 Discussion 9

3.1 Notes on Material Sources 9

3.2 Notes on Sample Preparation 9

3.3 Notes on Individual Tests 10

3.3.1 Wash Pass 75μm (Coarse Aggregate) - Test No. 1 10

3.3.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6 11

3.3.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8 12

3.3.4 Relative Density (Coarse Aggregate) - Test No. 9 and 12

Absorption (Coarse Aggregate) – Test No. 10 12

3.3.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11 12

3.3.6 Percent Crushed Particles - Test No. 12 13

3.3.7 Percent Flat and Elongated Particles – Test No. 13 13

3.3.8 Petrographic Number (Concrete) – Test No. 14 14

3.3.9 Petrographic Analysis of Fine Aggregate 15

3.3.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16 15

3.3.11 Freeze-Thaw Loss – Test No. 17 15

3.3.12 Sieve Analysis (Fine Aggregate) - Test Nos. 20-25 16

3.3.13 Relative Density (Fine Aggregate) – Test No. 27 and 16

Absorption (Fine Aggregate) – Test No. 28 16

3.3.14 Magnesium Sulphate Soundness (Fine Aggregate) - Test No. 29 17

3.3.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30 . 17

3.3.16 Moisture Density Relationship (One-Point Method) Test Nos. 31-33 17

3.3.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34 17

3.3.18 Particle Size Analysis of Soil - Test Nos. 40-45 18

3.3.19 Atterberg Limits of Soil – Test Nos. 46-48 18

3.3.20 Specific Gravity of Soil – Test No. 49 19

4.0 Laboratory Rating System 20

5.0 Conclusions 22

6.0 Recommendations 23

7.0 Acknowledgments 24

References 25
Appendix A: Glossary of Terms 26
Appendix B: List of Participants 28
Appendix C: Multi-Laboratory Precision Tables 42
Appendix D: Scatter Diagrams 47
Appendix E1: Results of Coarse Aggregate Petrographic Correlation 85
Appendix E2: Results of Fine Aggregate Petrographic Correlation 92
Appendix F1: Production Laboratory Ratings 96
Appendix F2: Full Service Aggregate Laboratory Ratings 101
Appendix F3: Soil Laboratory Ratings 103

Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office, runs an annual proficiency sample testing program for aggregate and soil tests. This provides a means for participating laboratories to see if they are performing satisfactorily. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected by the Soils and Aggregates Laboratory. The samples are delivered to the participating laboratories starting in July. The laboratories report their results starting in latter part of August. A preliminary report issued in early November, gives feedback to the participants while they are still operational in the current year. This allows them to examine their procedures or equipment and correct any problems that may have occurred. A final report is issued after analysis of the data has been completed.

This is the final report for the 2002 MTO Aggregate and Soil Proficiency Sample Testing Program. This year there were two hundred and fifteen (215) laboratories participating from the private and public sector. Of these, one hundred and fifty five were aggregate producer's and road builder's Quality Control (QC) Laboratories. Participation in this program is required by the contract documents if their QC process is to be acceptable to MTO. In general, these laboratories are conducting particle size analysis, wash pass 75 μm, percent crushed particles, percent asphalt coated particles, and density tests for granular base and sub-base aggregates.

Reports to individual laboratories contain ratings for each test method, which are based on the standardized deviate for that test (*i.e.* a rating of 5 for data within 1.0 standard deviation of the mean, a rating of 0 for data 3.0 or more standard deviations from the mean). Ratings for each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

Results of the 2002 Proficiency Sample Program show noticeable improvements compared to previous years' results. Particularly, the results of sieve analyses (coarse), wash pass 75-μm, Los Angeles abrasion, relative density and absorption (coarse & fine), magnesium sulphate soundness (coarse & fine), percent crushed particles, percent flat and elongated particles, one-point proctor and Micro-Deval (coarse) show improvements over previous years'. This is likely due, in part, to laboratory improvements brought about by the Canadian Council of Independent Laboratories (CCIL) inspection program of Aggregate Laboratories. Although there is noticeable improvement in results, strong laboratory biases still remain in a majority of the test procedures. The results of hydrometer and specific gravity of soil tests show marked improvements over previous years.

The Soils and Aggregates Section, continues to carry out the on-site inspection of soil-testing laboratories. The on-site inspection program was introduced in September 1999, in an effort

to improve the quality of soil and bridge foundation testing services provided to the ministry. This inspection is being done at the request of laboratories. The laboratories that are inspected and accepted for providing services to MTO must request for a re-inspection whenever the technician(s) or equipment changes. To date, thirty-four laboratories have been inspected, of which twenty-five laboratories have addressed the deficiencies that were identified and permitted to do testing in this field for MTO work.

1.0 Introduction

This is the final report of an annual inter-laboratory testing program organised by MTO for aggregate and soil test methods. It is primarily intended to provide a means for the MTO Laboratory and other laboratories used by MTO to see if they are performing satisfactorily and to qualify these laboratories to perform quality control and quality assurance testing for MTO contracts[1]. The design of the testing program is based on procedures for determining the precision and variability of test methods. Interested parties should refer to ASTM C670[2], C802[3], E177[4] and E178[5] for further information on inter-laboratory testing programs.

There were a total of two hundred and fifteen laboratories participating in this study, conducted in the summer of 2002. This included the MTO laboratory, the remainder being from the private sector, municipalities and other provincial governments. Samples were delivered to laboratories in early July. A preliminary report was issued in early November.

1 Laboratories must also be inspected and recognised by the Canadian Council of Independent Laboratories (CCIL).
2 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
3 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
4 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
5 ASTM E178 Practice for Dealing with Outlying Observations.

2.0Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, and 3. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples. (Note - when valid data is reported for only one of the samples in the pair, the test data is excluded from the statistical analysis and does not appear on the table of results).

Columns 4 and 5 show the mean (average) test value for each sample, for all laboratories performing the test, after removal of outliers and/or invalid test data.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\bar{x}$) from the actual test result reported by the laboratory (χ_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized deviate} = \frac{x_i - \bar{x}}{s}$$

If the test result is smaller than the mean, the standardized deviate is negative, and if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the other test result is

still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.
Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, *e.g.* sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see appendix). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.02) on the horizontal axis, against its test value for the second sample (2.02) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, this results in outlying points plotting off the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal cross-hairs on the plots represent the mean values for all the results on the first sample (1.02) and the second sample (2.02) respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from the expected circular distribution of points towards a linear distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results (Laboratory 47)

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: January 07, 2002					
COARSE AGGREGATE REFERENCE SAMPLES 1.02 & 2.02								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.02	2.02	1	2	1	2	1	2
LS-601 WASH PASS 75 µm (CA)	0.920	0.580	0.894	0.865	0.083	-1.469	5	-4
LS-602 % PASS 19.0 mm (CA) % PASS 16.0 mm (CA) % PASS 13.2 mm (CA) % PASS 9.5 mm (CA) % PASS 4.75 mm (CA)	 99.000 93.000 86.400 71.400 45.300	 98.600 92.100 85.500 69.500 40.580	 98.402 92.752 86.566 72.581 48.518	 98.401 92.801 86.575 71.554 44.688	 1.177 0.258 -0.147 -0.636 -1.133	 0.406 -0.797 -0.941 -1.308 -1.815	 4 5 -5 -5 -4	 5 -5 -5 -4 -3
LS-603 LOS ANGELES ABRASION %	25.400	25.200	24.200	24.273	0.792	1.070	5	4
LS-604 DR (CA-BULK S.S.D.) ABSORPTION (CA)	2.675 0.606	2.673 0.613	2.671 0.675	2.670 0.666	0.569 -0. 859	0.419 -0.667	5 -5	5 -5
LS-606 MGSO4 % LOSS (CA-MTO)								
LS-607 % CRUSHED PARTICLES	72.400	71.000	69.998	70.208	0.448	0.111	5	5
LS-608 % F & E PARTICLES	3.500	3.200	3.366	3.140	-0.091	0.028	-5	5
LS-609 PN (CONCRETE)	167.60	161.40						
LS-618 MICRO-DEVAL ABS (CA)	19.100	19.800	19.163	18.976	-0.103	0.883	-5	5
LS-614 FREEZE THAW, %	12.400	12.600	15.639	15.439	-0.734	-0.722	-5	-5

Blank spaces represent not tested.
* - calculation considered outlier

Table 2. Summary of Results (Laboratory 47)

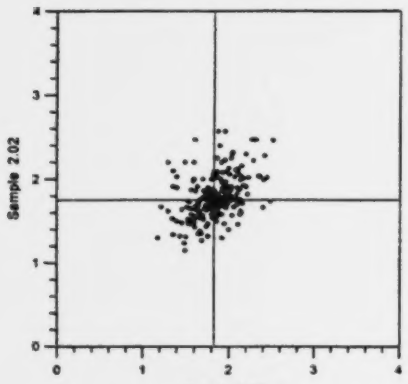
TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: January 07, 2002					
FINE AGGREGATE REFERENCE SAMPLES 3.02 & 4.02								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.02	4.02	3	4	3	4	3	4
LS-602								
% PASS 2.36 mm (FA)	37.700	32.300	40.126	36.577	-0.824	-1.683	-5	-3
% PASS 1.18 mm (FA)	30.800	26.800	32.907	29.846	-0.764	-1.307	-5	-4
% PASS 600 µm (FA)	22.300	19.900	24.194	21.887	-0.819	-1.029	-5	-4
% PASS 300 µm (FA)	12.800	11.700	13.580	12.436	-0.545	-0.534	-5	-5
% PASS 150 µm (FA)	4.500	4.400	4.901	4.549	-0.696	-0.229	-5	-5
% PASS 75 µm (FA)	1.580	1.470	1.852	1.779	-1.089	-1.112	-4	-4
LS-605								
DR (FA-BULK S.S.D.)	2.720	2.721	2.718	2.717	0.195	0.314	5	5
ABSORPTION (FA)	0.917	0.916	0.955	0.968	-0.206	-0.282	-5	-5
LS-606								
MGSO4 % LOSS (FA)								
LS-621								
ASPH COATED PARTICLES	27.900	46.200	28.151	41.856	-0.085	0.792	-5	5
LS-623								
MAX WET DENSITY g/cm^3	2.113	2.140	2.146	2.153	-1.153	-0.350	-4	-5
MAX DRY DENSITY g/cm^3	1.895	1.931	1.941	1.949	-1.377	-0.487	-4	-5
OPTIMUM MOISTURE, %	11.500	10.800	10.635	10.533	1.660	0.492	3	5
LS-619								
MICRO-DEVAL ABS (FA)	15.900	15.500	13.744	13.833	1.418	1.389	4	4

Blank spaces represent not tested.
* - calculation considered outlier

Table 3. Summary of Results (Laboratory 47)

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: Feb. 14, 2002					
SOILS REFERENCE SAMPLES 5.01 & 6.01								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	5.01	6.01	5	6	5	6	5	6
LS-702								
% PASS 2.00 mm (SOIL)	100.00	99.900	100.00	99.977	0.000	-1.170	5	-4
% PASS 425 µm (SOIL)	99.100	96.600	98.349	96.339	1.192	0.554	4	5
% PASS 75 µm (SOIL)	93.800	89.000	92.552	88.665	1.665	0.873	3	5
% PASS 20 µm (SOIL)	62.200	72.500	63.557	70.232	-0.338	0.556	-5	5
% PASS 5 µm (SOIL)	44.600	47.500	44.995	44.723	-0.103	0.923	-5	5
% PASS 2 µm (SOIL)	35.100	31.000	33.402	31.085	0.446	-0.067	5	-5
LS-703								
LIQUID LIMIT, %	38.100	28.300	34.105	27.459	1.381	0.532	4	5
LS-704								
PLASTIC LIMIT, %	19.000	16.100	17.818	15.522	0.680	0.408	5	5
PLASTICITY INDEX, %	19.100	12.200	16.227	11.916	1.002	0.200	4	5
LS-705								
RELATIVE DENSITY	2.753	2.754	2.713	2.732	1.161	0.836	4	5
LS-706								
MAX WET DENSITY g/cm^3								
MAX DRY DENSITY g/cm^3								
OPTIMUM MOISTURE, %								

Blank spaces represent not tested.
* - calculation considered outlier

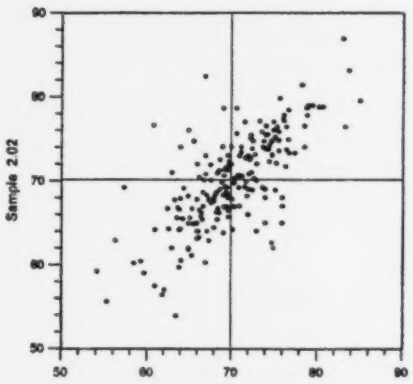


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	1.852	1.779
Median	1.900	1.760
Std Dev	0.250	0.273
n = 204		

Labs Eliminated: 447, 497, 518, 452

Scatter diagram for a test showing random variation with little Laboratory bias

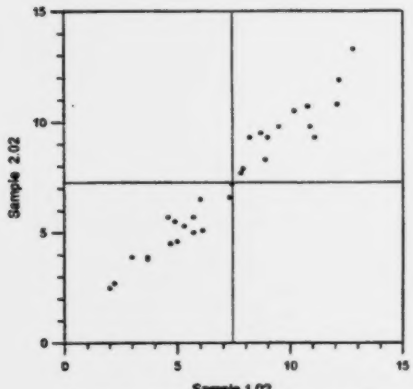


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	69.998	70.208
Median	69.750	70.350
Std Dev	5.356	5.807
n = 186		

Labs Eliminated: 350, 345, 436,480

Scatter diagram for a test showing a combination of random variation and laboratory bias for some Laboratories

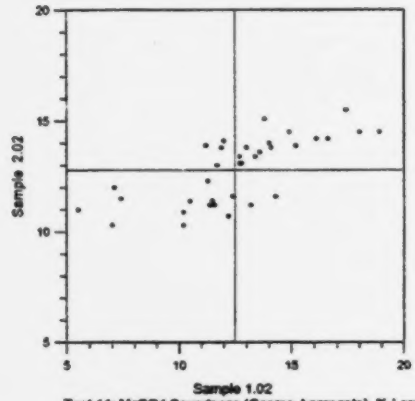


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	7.452	7.303
Median	7.400	7.700
Std Dev	3.245	2.844
n = 31		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	12.568	12.786
Median	12.700	13.100
Std Dev	3.005	3.169
n = 65		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1 Examples of Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', our purpose is to remove those observations that do not belong to the sample population and to provide some statistical criteria for doing so. There are a number of ways to do this. In most of these, as ASTM E178 states, 'the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected. The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution or universe.'

The MTO study follows the Three Standard Deviation technique to identify outliers. In this technique, after screening the test data for any non-compliance with the test procedure or calculation errors, the doubtful test result is included in the computation of mean and standard deviation of the sample population, i.e., data set. The absolute values of standardised deviate for all the test results in the data set are then calculated and the largest standardised deviate is compared with a numerical value of three (3). The test result with the largest standardised deviate is rejected or identified as an outlier, if the standardised deviate is higher than three (3). The outlier is removed from the data set and the iterations are continued until no outliers are detected, and a revised mean and standard deviation are calculated after deleting each outlier. The ratings of the laboratories are determined based on the revised mean, standard deviation and standardised deviate.

We are in some cases handicapped due to a low number of laboratories participating in some tests, when the strict application of the three standard deviation criteria tends to include laboratories in the population who are not doing a good job. In these cases, the application of the iterative (jack-knife) technique recommended by Manchester[6] is used. In this method, after screening the test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and test result farthest from the mean by a unit of Cs (standard deviation (s) multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of Three Standard Deviation technique. The significance level in this method of analysis depends on the number of laboratories, and the level of significance will be between 1 % and 2.5 %.

6 EM-33, The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office, Downsview, December, 1979.

3.0 Discussion

The following discussion contains general and test-specific comments for the 2002 test period. Where ASTM precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in an appendix.

3.1 NOTES ON MATERIAL SOURCES

Materials used in this test period were as follows:

- Coarse and fine aggregate tests, including Sieve Analysis, Percent Crushed Particles (CA), Relative Density and Absorption (FA), Moisture Density Relationship, Micro-Deval Abrasion Loss (FA), Los Angeles Abrasion (CA), and Magnesium Sulphate Soundness (FA) – Granular 'A' from Georgian Hanover Pit (MTO MAIDB No. D06-118, Georgian Aggregates & Construction Inc.).
- Coarse Aggregate tests, including Wash Pass 75 μm, Percent Flat and Elongated Particles, Relative Density and Absorption, Magnesium Sulphate Soundness, Petrographic Analysis, Micro-Deval Abrasion Loss, and Freeze - Thaw – HL8 Stone from Brechin Limestone Quarry (MTO MAIDB No. O11-047, Lafarge Canada Inc.).
- Fine Aggregate Petrographic Examination – Concrete sand from Erie Sand & Gravel, Leamington Pit (MTO MAIDB No. E02-020).
- Soil tests – Clayey soil from "Caradoc Sand Plain" Physiographic Region located near Hwy. 402 and Regional Road 39 in Township of Adelaide for Sample 1.02S and "Huron Slope" Physiographic Region located near Parkhill in West Williams Township for Sample 2.02S.

3.2 NOTES ON SAMPLE PREPARATION

The material processed for the aggregate tests conforms approximately to a granular 'A' gradation. The aggregate samples were prepared using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, dated February 2000). Twenty-five tonnes of granular 'A' were placed in layers into five separate stockpiles. A bobcat loader was used to fill an aggregate bin with small scoops from each stockpile in turn, in order to minimize sample bias. Material was fed along a conveyor belt to fill 30 identical buckets on a spinning turntable. It was found that

18 to 22 revolutions of the turntable were required to fill each bucket to approximately 30 Kg. This resulted in more homogeneity of the samples than would normally be the case using other techniques. In total, five hundred 30 Kg samples were prepared and randomised for distribution to participating laboratories. The participants were responsible for the preparation of their own fine aggregate samples (3.02 and 4.02) from the two bags of granular 'A' delivered.

The soils from sources identified in Section 3.1 were air-dried, processed passing 2.0 mm using a Fritsch Soil Mill Pulverizer, and placed in 20 Kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter. The splitter used is capable of filling 24 identical 2 Kg containers per run. This method was used to create uniform 20 Kg buckets. The 500 g correlation materials were prepared by obtaining representative samples from each bucket using the scoop method. Then the samples were randomised for distribution to participating laboratories. The use of a spinning riffler ensured that as far as possible, each sample was identical to every other sample. It has been found that this is the best technique for minimising sample bias.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the scatter diagram. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables, found in the appendix. Besides the comparison made to ASTM precision statements, comparison of the variation between test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasised that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.3.1 Wash Pass 75 μm (Coarse Aggregate) – Test No. 1

Two hundred and eight laboratories participated in this test. Sixteen outliers were identified and rejected using the three standard deviation technique. The standard

deviation is slightly higher than in 2000 and 2001 and within the range of values published by ASTM. The scatter diagram shows random variation with noticeable laboratory bias. However, the number of outliers (16) in 2002 is considerably lower than (35) in 2001.
The laboratories that are identified as outliers must examine their test procedure more closely.

3.3.2 Sieve Analysis (Coarse Aggregate) – Test Nos. 2-6

These tests represent the coarse aggregate portion of the sample gradation. Tests 20-25, carried out on the material passing 4.75 mm as prepared by the participants (samples 3.02 and 4.02), represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[7].

The samples were prepared with a large spinning riffler that is described in Section 2.2. This method of preparation minimises the sample variation and has resulted in no observable gradation difference between samples 1.02 and 2.02. The variations found in 2002, with the exception of the per cent passing the 4.75 mm sieve, are similar or comparable to that of 2001 and also significantly less than the expected variation given in the ASTM precision statements.

The standard deviation for 4.75 mm sieve (2.2 & 2.7) is significantly higher than in previous years and the value published in ASTM. The points in the scatter diagram for this test (Test No. 6) are concentrated in two distinct areas about the cross-hair of Sample 1.02 with a gap in the middle, indicating a bi-modal distribution of the data. Such a data distribution may have resulted from the variation in samples distributed and this may be the cause for the higher standard deviation.

Two hundred and eleven labs carried out the sieve analysis test. Outliers were eliminated using the three standard deviation technique. Successive scatter diagrams show a fairly uniform distribution of points about the mean and only three to seven laboratories had reported results that deviated considerably from the mean.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E-11 as guides) and your sieve shaker(s) thoroughly, and once satisfied that they are in order, perform a sieving efficiency test (MTO Method LS-602, Note 5) to pinpoint any problems.

7 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

3.3.3 Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only thirteen laboratories participated in this test. Two outliers were eliminated using the iterative technique. The lower left and upper right quadrants together account for twelve of the thirteen points, which is evidence of strong laboratory biases. This test shows systematic variation, as was found in previous years, however, the variation is similar to that found in 2001 and significantly less than in prior years. However, the standard deviation of samples 1.02 (1.68) is twice that of sample 2.02 (0.87).

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range 10 to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, results from two different laboratories should not differ by more than 12.7%. The mean in this test (24.2%) is in the range of values for which ASTM data was established, and comparison indicates that this year's variation is comparable to that of ASTM precision statements.

3.3.4 Relative Density (Coarse Aggregate) - Test No. 9 and Absorption (Coarse Aggregate) – Test No. 10

Ninety laboratories participated in these tests in 2002. Nine laboratories in the Test No. 9 and four laboratories in Test No. 10 were eliminated using the three standard deviation technique. The variation for each of these tests is same as the values in the 2001 study, and considerably less than the values given in the ASTM precision statements. It is noteworthy that precision has improved markedly compared with values obtained in 1997, prior to implementation of a Province-wide laboratory inspection and certification program. However, in both tests, a majority of the points are located in the 1st and 3rd quadrants of the scatter diagrams indicating significant laboratory bias.

3.3.5 Magnesium Sulphate Soundness (Coarse Aggregate) – Test No. 11

Thirty-five laboratories performed this test in 2002, and no outlier was selected using the three standard deviation technique or iteration technique. The scatter diagram shows a strong laboratory bias and all the points, with the exception of six, are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The coefficient of variation in 2002 (24.5%) is significantly lower than in previous three years (31.6% to 37.6%). The coefficient of variation is within the range of value reported in ASTM precision statements, which report a coefficient of variation of 25% for the percent loss range of 9 to 20.

3.3.6 Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

The test method MTO LS-607 was revised in 2001, and the participants were provided with the draft copy of the revised version. They were advised to perform the test in accordance with Method B on material passing the 19.0 mm sieve.

Two hundred and eight laboratories performed the percent crushed particles test this year. Twenty-two outliers were selected by the three standard deviation technique. The number of outliers identified this year is slightly lower than in 2001 study (26), and considerably higher than in years prior to 2001. The number of outliers remains high, and this may be due to misinterpretation of the test method or instructions provided. Variation is slightly less than the values obtained during 1989 MTO workshop[8]. The mean in this test (70.1) is within the range of values (50 to 75) for which MTO data was established. The scatter diagram shows a random variation with significant laboratory bias. The sample sent did not contain any cemented particles; therefore the percent cemented particles test was not evaluated this year. ASTM has a very similar test method (D 5821) but has not conducted inter-laboratory studies to determine precision and currently publishes precision data obtained from MTO.

3.3.7 Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test.

The test method MTO LS-608 was revised in 2001, and the participants were provided with the draft copy of the revised version. They were advised to perform the test in accordance with the revised procedure on material passing the 19.0 mm sieve.

One hundred and sixty four laboratories reported test results in 2002. The three standard deviation technique was used to reject nineteen outliers. The number of outliers is significantly higher than in previous years. The standard deviation is slightly lower than in 2001, and the amount of flat and elongated particles is also comparable to the amount reported in 2001. The lower standard deviation indicates an improvement in overall performance. ASTM and CSA do not report precision for this test.

8 MI-134, Determination of Crushed Particles for Test Method LS-607, by Price, Gage and Junor, Ministry of Transportation, Ontario, Engineering Materials Office, Downsview, March 1989, ISBN-0-7729-5558-1.

3.3.8 Petrographic Number (Concrete) – Test No. 14

The coarse aggregate examined in 2002 was HL stone from the Lafarge Canada Inc. Brechin quarry (MTO MAIDB Number O11-047).

Analysts from thirty-one laboratories examined samples 1.02 and 2.02 (full fraction), and submitted work sheets showing subdivision according to rock type and quality. Laboratories 13, 80, and 196 used the same analyst, as did 19 and 175; and 101 and 203. Laboratories 15, 39, 112, and 172 used outdated work sheets. The results are shown in the appendix and were evaluated by D.A. Williams, MTO Petrographer.

The samples contained approximately 70% good aggregate (approximately 10% slightly cherty carbonate, the balance being mainly hard carbonate and medium hard carbonate). Values of good aggregate content of more than 80% were reported by all laboratories except 23 (1.02 only), 47, 112 (2.02 only), 150, and 188. Values of slightly cherty carbonate content of less than 2% were reported by all laboratories except 13 (2.02 only), 23, 47, 72 (1.02 only), and 150. 100% hard or medium hard volcanic (a rock type which was not present in the samples) was reported by laboratories 19 and 175.

The samples contained approximately 28% fair aggregate (approximately 5% cherty carbonate and chert, the balance being mainly soft or slightly shaley carbonate). Values of fair aggregate content of less than 20% were reported by all laboratories except 23 (1.02 only), 47, 112 (2.02 only), 150, and 188. Values of cherty carbonate and chert of 0.5% or less were reported by all laboratories except 31 and 47.

The samples contained approximately 2% combined poor and deleterious aggregate. The poor aggregate consisted of shaley carbonate, and the deleterious aggregate of shale.

A need for all laboratories except 23, 47, 112, 150, and 188 to modify their rock quality classification system is indicated. For many of the laboratories, failure to soak the samples for at least 15 minutes (as noted in the test method) immediately before examination was probably the cause of the failure to recognise significant amounts of soft or slightly shaley and shaley carbonate which in turn resulted in low petrographic numbers.

No outlier was selected using either iterative or three standard deviation technique, but notes are made on the scatter diagram about laboratory abilities. The laboratories that have reported low petrographic numbers need to improve their ability to recognise different type of rocks, particularly the presence of shaley and slightly shaley carbonate.

The similar ASTM standard for this test, C-295, does not report a petrographic number and has no precision statement.

3.3.9 Petrographic Analysis (Fine Aggregate)

The fine aggregate examined in 2002 was concrete sand from the Erie Sand and Gravel Leamington pit (MTO MAIDB Number E02-020).

Analysts from nine laboratories examined samples 1.02 and 2.02, and submitted work sheets showing subdivision according to rock/mineral type (silicate, carbonate, shale, mica, chert, contamination, and cementation) and sieve size. Laboratories 80, 101, and 203 used the same analyst. The results are shown in the appendix and were evaluated by D.A. Williams, MTO Petrographer.

The samples contained an average of approximately 40% silicate, 20% carbonate, 35% shale, 2% mica, and 3% chert (silicate and mica contents increased from larger to smaller sieve sizes, and shale and chert contents decreased). Values of silicate content of greater than 60% were reported by Laboratory 35; carbonate content greater than 30% by Laboratory 37; shale content less than 20% by Laboratories 35 and 37; and chert content less than 1% by Laboratories 35 and 37 (1.02 only).

A need for Laboratories 35 and 37 to modify their rock/mineral type classification system is indicated. Only nine laboratories have reported results for this test, because of this no statistical analysis was performed.

The similar ASTM standard for these tests, C-295, has no precision statement.

3.3.10 Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Sixty-six laboratories reported results for this test in 2002. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, two laboratories reported control sample results outside the established range and those two labs were excluded from the analysis. Two outliers were rejected using the three standard deviation technique. The standard deviation (0.95) and coefficient of variation (4.9%) are slightly lower than the multi-laboratory standard deviation 1.1 and coefficient of variation of 5.2%, published in the test method (LS-618).

3.3.11 Freeze-Thaw Loss – Test No. 17

Fifty-two laboratories reported results for this test. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratory to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, section 9.1). This year, two laboratories reported control sample data outside the established range, and those two labs were excluded from the analysis. No outlier was selected using either three standard deviation or iterative technique. Variation is considerably higher than multi-laboratory precision statements published in LS-614. The scatter diagram shows evidence of a

strong laboratory bias for this test. It is likely that there are two main reasons for the wide spread in data: insufficient damage caused by freezing which is due to freezing too rapidly or difference in sieving intensity. Laboratories should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. LS-614, Revision 20 (Appendix 1) in the MTO Laboratory Testing Manual gives a procedure for determining and adjusting sieving time for quantitative analysis.

3.3.12 Sieve Analysis (Fine Aggregate) – Test No. 20-25

The samples for this procedure were prepared by the participants from the material r sing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows normal testing procedure in which the laboratory prepares its own test samples from t field sample. The scatter diagrams for the fine aggregate sieve analysis show random variation, except for the 75 μm fraction, where some systematic bias due to operator/laboratory differences is apparent. However, the standard deviation for Test No. 20 to 23 is considerably higher than in previous years and the values published in ASTM. As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained on the sieve, the more efficient the sieving process, and the better the precision. When there is a small amount of material on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

Outliers were selected using the three standard deviation technique. Outlier labs with very low percent passing the 75 μm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing the sieve.

3.3.13 Relative Density (Fine Aggregate) – Test No. 27 and Absorption (Fine Aggregate) – Test No. 28

Eighty-six laboratories performed these tests in 2002. The scatter diagrams for these tests show systematic variation. Nine outliers for Test No. 27 and five outliers for Test No. 28 were selected using the three standard deviation technique. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is thought that the differing technique in arriving at the saturated surface dry condition (towelling for coarse aggregate vs. air-current drying and continuous stirring for fine aggregate) is responsible for this variation. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30 seconds periods of rest can be detrimental for the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state. The resulting test observations are lower relative densities and higher absorption values. The multi-laboratory variation of the relative density test is less than the variation stated in ASTM C128.

This test shows gradual improvement in precision since 1997. In both cases, the coefficient of variation has noticeably reduced since 2000 study (Test No. 27 from 0.6% to 0.5% and Test No. 28 fro 29.2% to 17.7%). This is probably due to generally improved equipment and operator performance as a result of the laboratory inspection process. However, strong laboratory bias still exists.

3.3.14 Magnesium Sulphate Soundness (Fine Aggregate) – Test No. 29

Thirty-one laboratories participated in this test in 2002. No outlier was detected using the three standard deviation technique or iterative technique. All the data, with the exception of one, are accounted in the lower left (quadrant 3) and upper right (quadrant 1) with the axis of scatter of points at approximately 45 degrees. As in previous years, the scatter diagram shows strong laboratory bias.

3.3.15 Amount of Asphalt Coated Particles in Coarse Aggregate – Test No. 30

This test was included in the Correlation Program in 2001. Samples RAP 1.02 and RAP 2.02 that were distributed in 2002 were prepared with different proportion of asphalt coated particles. Two hundred and nine laboratories reported results for this test. Seven laboratories were selected as outliers using the iterative technique. The scatter plot shows combination of random variation and laboratory bias for some of the laboratories. The laboratories that are located in the lower 3rd quadrant of the plot may have reported results by testing one sample only. There is no comparable or similar ASTM test procedure, and no precision statement has been established by MTO.

3.3.16 Moisture-Density Relationship (One-Point Method) – Test Nos. 31-33

One hundred and forty four laboratories reported results for this procedure. The outliers were rejected using the three standard deviation technique. The number of laboratories selected as outliers (8 to 14) is lower than in 2001. However, the number of outliers remains higher than in years prior to 2001. The scatter plots show improvement over previous years, however, significant laboratory bias still remains. The possible causes for the bias may be misinterpretation of the test method and use of an improper mould even though, the participants were requested to use only the material passing 4.75 mm sieve and a 152.4 mm diameter mould. In addition, this test requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. Variations in this study is almost similar to that was in 2001. There are no ASTM precision statements for these tests.

3.3.17 Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants were asked to prepare their own test sample from the bulk sample provided. Sixty-three laboratories participated in this test in 2002. The test method requires

reporting of control sample test results to demonstrate that the testing process is in control. All laboratories reported control samples within the acceptable range. The scatter diagram shows systematic bias. Two outliers were selected using the three standard deviation technique. The standard deviation (1.2) as well as the coefficient of variation (9.4%) is slightly higher than in 2001 (0.9 and 8%) and the multi-laboratory coefficient of variation (6%) published in the test method (LS-619).

3.3.18 Particle Analysis of Soil – Test Nos. 40-45

As indicated in Section 3.1, the samples S1.02 and S2.02 for 2002 study were selected from two different sources. Seventy-five laboratories carried out the hydrometer test in 2002. Test 40 is reported for information purposes only, because 87 percent of laboratories reported 100% passing 2.00 mm. Outliers were selected using the three standard deviation technique. Participants were requested to perform the test according to MTO LS-702, Revision No.19 and to verify this, they were asked to submit the data sheet. Based on the data sheet, six laboratories did not perform the test in accordance with test procedure and these were excluded from the analysis.

The scatter diagrams show noticeable improvement compared to previous years, however, significant laboratory biases, especially in the case of percent passing 2μm and 5μm, still remain. The standard deviations for each of these particle sizes are more or less similar to that were in 2001, and are significantly lower than in years prior to 2001.

The laboratories that are identified as outliers should examine their equipment and procedure very carefully to make certain all is within specification and the procedure is followed exactly.

3.3.19 Atterberg Limits of Soil – Test Nos. 46-48

Seventy-eight laboratories reported Atterberg Limits for soil in 2002. Seven outliers were identified using the iterative technique. The scatter plots for both Liquid and Plastic Limits show systematic variation. This variation is characteristic of tests that require significant operator skills, and good condition and calibration of the apparatus. In previous years, with the exception of 1999, the standard deviation for the liquid limit test has always been higher than for the plastic limit, and the same trend is reflected in this year's results. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce these biases.

As noted under the Particle Analysis of Soils (Test No. 40 to 45), soils from two different sources with differing plastic properties were distributed. In all three tests, the standard deviation of S1.02, i.e., Sample 1, is considerably higher than that of S2.02, and higher than in previous years. The difference in standard deviation is very significant for both liquid limit and plasticity index and this may have caused by labs that are located in the upper left-hand quadrant of the scatter diagram. Some of these labs may have mixed up

the results for samples 1.02S and 2.02S, and others may have reported results by testing one sample only.

This year, variations for all three tests, i.e., liquid, plastic limits, and plasticity index are significantly higher than in previous years. ASTM has recently revised the precision statements for this test, based on results from twenty-four laboratories. The standard deviation is significantly higher than the values that are now published in ASTM for samples tested for liquid limit, and in the case of plastic limit, it is reasonably close to that of ASTM.

3.3.20 Specific Gravity of Soils – Test No. 49

Sixty-five laboratories reported results for this test. The participants were requested to perform the test on minimum of three specimens in accordance with the procedures described in Section 7.1of MTO LS-705, Revision No. 20. They were asked to submit the data sheet to verify if the range, i.e., the difference between the largest and smallest value, is within the limit specified in the test method. Based on the data sheet, seven laboratories were excluded from the analysis for exceeding the limit. Two outliers were detected using the iterative technique. The scatter plot shows improvements compared to previous years, however, some laboratory bias still remains. Several steps in this test procedure can influence the results. Particularly, the equipment and method employed for preparation of test specimen as well as for removal of air entrapped in the pycnometer or flask. The possible cause for the bias may be because the laboratories do not fully comply with the test procedures. Laboratories finding themselves in this situation should examine their equipment and procedure very carefully.

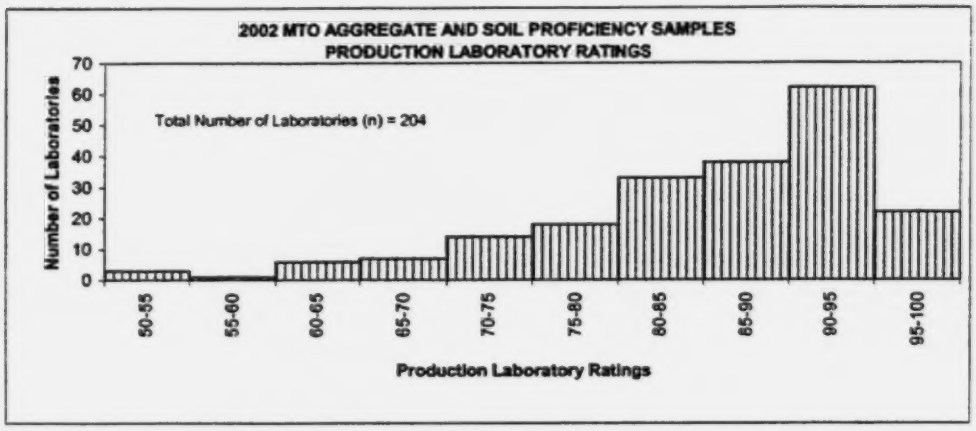
The standard deviation in 2002 is similar or comparable to that of 2001. These values are considerably less than found prior to 2001 and the multi-laboratory variation limit specified in the ASTM precision statement for the test.

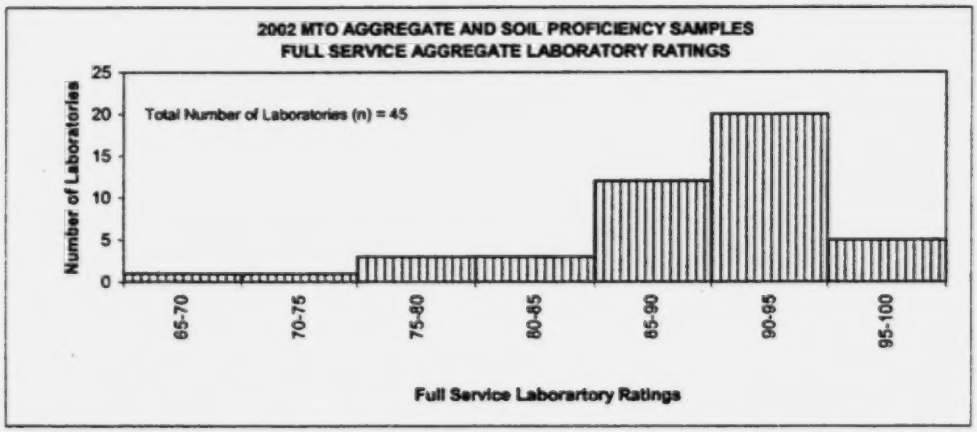
4. Laboratory Rating System

The laboratory rating system, applied to all participating laboratories, was devised in 1997. The rating system assigns separate laboratory ratings for low complexity (production) aggregate laboratories, high complexity (full service) aggregate laboratories, and for soil laboratories. Low complexity laboratories are required to carry out wash pass 75 μm, gradation, percent crushed particles, percent asphalt coated particles, and optional, percent flat and elongated particles. In addition to those low complexity tests, high complexity laboratories must carry out micro-Deval (coarse and fine), freeze-thaw and/or magnesium sulphate soundness, relative density and absorption (coarse & fine). Forty-five (45) high complexity (full service) aggregate laboratories participated in the program in 2002. Soil laboratories are required to carry out particle size analysis, Atterberg limits and specific gravity of soil. Fifty-five soil laboratories have participated in all three tests in 2002.

The rating system gives a maximum of 10 for each test, *e.g.* 5 for wash pass 75 μm on sample 1.02, plus -5 for wash pass 75 μm on sample 2.02, equals 10 (the negative sign indicating a test result less than the mean is ignored). Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the gradation results, the ratings (out of 10) for each sieve, coarse and fine, are multiplied by three so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by the number of sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Aggregate and soil laboratory ratings are given in Figure 2 in the form of charts. The laboratory rating system data is reported in the appendix.

Laboratory ratings are given in the covering letter accompanying this report to individual laboratories. A poor or good rating for a laboratory in one year is an indication of how that laboratory performed in the proficiency study, and may not be a reflection of how the laboratory performs year round. A consistently poor rating over two or more years may be cause for serious concern.





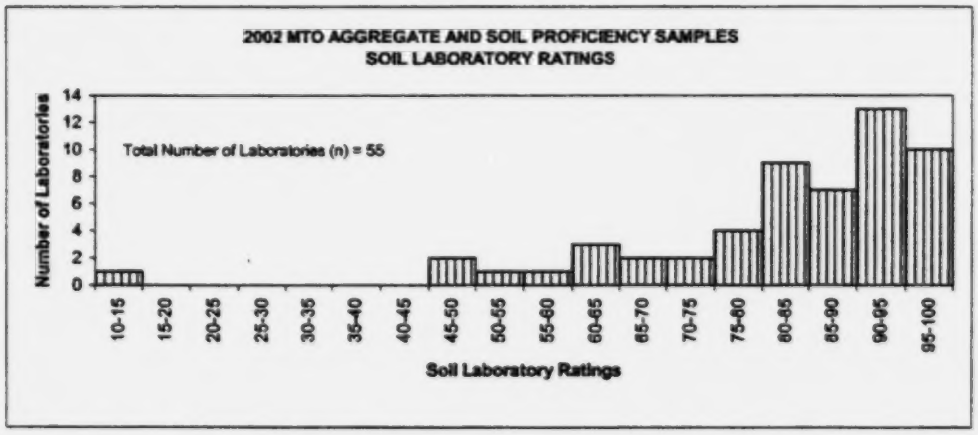


Figure 2 Laboratory Ratings

5. Conclusions

Since 1999, the samples have been prepared with a large spinning riffler. This method of sample preparation resulted in no significant (coarse aggregate) mean gradation differences between samples 1.02and 2.02. In fact, variations for sieve analysis results since 1999 are similar or significantly lower than the variations given in the ASTM precision statements. The differences in mean as well as in variations between pairs of samples for both, coarse and fine sieves, are none to negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform material at reasonable cost.

In addition to the sieve analysis results, other test results of the 2002 Proficiency Sample Program not only compare favourably but also in many cases show noticeable improvement over previous year's results. These tests include the wash pass 75 μm, Los Angeles abrasion, relative density and absorption (coarse and fine), magnesium sulphate soundness (coarse & fine), percent crushed particles, percent flat and elongated particles, one-point proctor and Micro-Deval (coarse). These aggregate tests are probably showing improvement, in large part, due to the CCIL laboratory inspection and certification program, which began in 1998, and due to an increased awareness of the importance of proper testing. Aggregate quality has a larger effect on the variation exhibited in some tests, and a smaller effect in others. For example, the Micro-Deval Abrasion test exhibits increased variation as higher total loss is reported. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percentage passing and the variation being remarkably similar for the two samples.

In the case of hydrometer analysis, the number of participants has decreased from eighty-seven to seventy-five, whereas in specific gravity test, the increase is marginal (63 to 65). The results of particle size analysis and specific gravity of soil, show marked improvements over previous years. In contrast, the variations in Atterberg limit results are significantly higher than in previous years and the values published in the ASTM. Specific gravity results show significantly lower variation than in previous years and the values published in the ASTM precision statement. The soil tests are probably showing noticeable improvement, in part, due to revised test procedures for MTO LS-702 and LS-705, and to a certain extent the soil laboratory inspection program, which MTO implemented in 1999. In addition, it may be due to increased awareness of the importance of proper testing. It is expected that the soil laboratory inspection process that is being carried out by MTO[9] will bring about improvements in variation.

9 To arrange an inspection of your Soil Laboratory, please contact Mark Vasavithasan, Soils and Aggregates Section, Ministry of Transportation, phone (416) 235 – 4901, fax (416) 235 – 4101.

6. Recommendations

Although, there are noticeable improvements in the results, strong laboratory biases still remain in majority of the test procedures. In addition, the number of laboratories identified as outliers in wash pass 75μm, percent crushed particles, percent flat and elongated, one-point proctor, particle analysis of soil and specific gravity of soil tests remains considerably high. These laboratories should examine the condition and calibration of equipment, testing procedures, and skills of the technicians.

The results of the 2002 MTO Aggregate and Soil Proficiency Sample Program suggest that most laboratories have satisfactory within-laboratory precision, but the multi-laboratory precision needs to be improved for a number of the tests. The laboratories must focus on operator training, standardization and calibration of equipment, and laboratory environment in order to improve the multi-laboratory precision.

For all of the tests that were included in this study, the equipment to be used is regulated by the method itself. A good state of maintenance, repair and the correct calibration are sometimes lacking. It is hoped that the Quality System implemented by CCIL in the spring of 2002 will go some way that the laboratories conduct self-examination to ensure they have the correct equipment and trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration, and testing of control or reference samples, are beneficial to maintaining a high level of confidence in their results.

8. Acknowledgments

The authors wish to acknowledge the assistance and dedicated work of the laboratory staff of Soils and Aggregates Section in preparation of samples and performing the tests. We received considerable assistance from the laboratory staff of Bituminous Section and Concrete Section in preparation of correlation samples for distribution, without their help, the task would have been much more difficult.

References

1. American Society for Testing and Materials 2002. Annual Book of ASTM Standards, Vol. 04.02, Concrete and Aggregate
2. American Society for Testing and Materials 2002. Annual Book of ASTM Standards, Vol. 14.02, Statistical Methods
3. L. Manchester, 1979, "The Development of an Interlaboratory Testing Program for Construction Aggregates", Engineering Materials Office Report 6 EM-33, Ministry of Transportation, Ontario
4. R. H. Vogler and P. A. Spellenberg, "AASHTO T 27 – Sieve Analysis of Fine and Coarse Aggregate", Technical Section 1c, Unpublished Paper

Appendix A: Glossary of Terms

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value.' This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process, and an accepted reference value of the property being measured. For the majority of aggregate and soil tests there is no acceptable reference material, so bias is impossible to compute.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$$

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Multi-laboratory precision (one-sigma limit (1s)) is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances the estimates of the one-sigma limit for multi-laboratory precision are usually larger than those for single operator precision because different operators and different equipment are being used in different laboratories.

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s), by the factor $2\sqrt{2}$ (2.83).

Sample mean or average is the sum of all observations divided by the total number of observations.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the **sample median** is the *single middle value* in the ordered list, if n is

odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier it means something went wrong either with the sample or in the laboratory.

Appendix B: List of Participants

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
A. L. Blair Construction Limited Moose Creek, ON Mr. B. Blanshard Tel: 613 538-2271	✓	✓				✓	✓							✓				
Acculab Engineering and Testing Schumacher, ON Mr. H.R. Jones Tel: 705 360-5252	✓	✓		✓		✓	✓							✓				✓
Acres International Limited Niagara Falls, ON Mr. R. Serluca Tel: 905 374-5200														✓	✓	✓	✓	
AGS Associates Inc. Scarborough, ON Mr. A. Chohan Tel: 416 299-3655	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
AME - Materials Engineering – East Gormley, ON Mr. B. Dobson Tel: 905 887-1469	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓
AME - Materials Engineering (24-911) Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓								✓				✓
AME - Materials Engineering (24-912) Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓								✓				
AME - Materials Engineering Mobile 1 (24-270), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓	✓							✓				✓
AME - Materials Engineering Mobile 2 (24-165), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓								✓				✓
AME - Materials Engineering Mobile 3 (24-272), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓								✓				✓
AME - Materials Engineering Mobile 5 (24-298), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓	✓							✓				✓
AME - Materials Engineering Mobile 6 (24-271), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓	✓							✓				✓
AME -Materials Engineering Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
AME -Materials Engineering - Ottawa Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓	✓							✓				✓
AME -Materials Engineering Mobile 7 (24-297), Brampton, ON Mr. T. Dziedziejko Tel: 905 840-5914	✓	✓				✓	✓				✓	✓		✓				
AMEC Earth & Environmental Ltd Scarborough, ON Mr. S. Sufi Tel: 416 751-6565	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd Windsor, ON Mr. C. Ellsworth Tel: 519 969-7530	✓	✓		✓		✓								✓				
AMEC Earth & Environmental Ltd. Hamilton, ON Mr. J. Balinski Tel: 905 312-0700	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. London, ON Mr. S. Burt Tel: 519 681-2400	✓	✓				✓	✓							✓				✓
AMEC Earth & Environmental Ltd. Orillia, ON Mr. L. Knegt Tel: 705 329-1542	✓	✓				✓	✓							✓	✓			✓
AMEC Earth & Environmental Ltd. Thorold, ON Mr. A. Markov Tel: 905 687-6616	✓	✓				✓	✓							✓	✓	✓	✓	✓
AMEC Earth & Environmental Ltd. Waterloo, ON Mr. L. Maier Tel: 519 885-6220	✓	✓				✓								✓				✓
Ashwarren Engineering Services Ltd Mississauga, ON Mr. K. Wells Tel: 905 819-1290	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓				✓
Bernt Gilbertson Enterprises Richards Landing, ON, Mr. S. Eddy Tel: 705 246-2076	✓	✓				✓								✓				
Bertrand Construction L'Original, ON Mr. G. Downing Tel: 613 675-4614	✓	✓				✓	✓				✓	✓		✓				
Block & Associates Winnipeg, MB Mr. K. Kulchyski Tel: 204 334-5356	✓	✓	✓	✓	✓	✓	✓							✓	✓	✓	✓	✓
Brock Aggregates Inc. Concord, ON Mr. D. Santoro Tel: 800 870-8926	✓	✓																
Bruno's Contracting (Thunder Bay) Ltd. (#358), Thunder Bay, ON Mr. B. Prevost Tel: 807 623-1855	✓	✓				✓								✓				

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Bruno's Contracting (Thunder Bay) Ltd. (#376), Thunder Bay, ON Mr. B. Prevost Tel: 807 623-1855	✓	✓				✓								✓				
C. Villeneuve Construction Hearst, ON Mr. C. Harris Tel: 705 372-1838	✓	✓				✓								✓				
C.T. Soil & Materials Engineering Inc. Windsor, ON Mr. R. Primeau Tel: 519 966-8863	✓	✓				✓								✓	✓			✓
Caledon Sand & Gravel Ltd. Caledon, ON Mr. D. Glenn Tel: 905 457-4537	✓	✓				✓								✓				
Capital Paving Inc. (Aggregate Lab) Guelph, ON Mr. M. Latyn Tel: 519 822-4511	✓	✓				✓	✓							✓				✓
Capital Paving Inc. (Asphalt Lab) Guelph, ON Mr. M. Latyn Tel: 519 822-4511	✓	✓				✓	✓							✓				✓
Cayuga Materials & Construction Co. Ltd Cayuga, ON Mr. G. Taylor Tel: 905 772-3331	✓	✓		✓		✓	✓				✓	✓		✓				✓
CBM Aggregates Aberfoyle Lab Cambridge, ON Mr. L. Mugford Tel: 519 824-5384	✓	✓				✓								✓				
CBM Aggregates London Lab London, ON Mr. L. Mugford Tel: 519 285-2583	✓	✓			✓	✓	✓			✓	✓	✓		✓				
CBM Leaside Lab Toronto, ON Mr. S. Parkes Tel: 416 423-2439	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
CBM Sunderland Lab Sunderland, ON Mr. L. Mugford Tel: 416 862-1382	✓	✓				✓								✓				
Chung & Vander Dollen Engineering Limited Kitchener, ON Mr. E. Chung Tel: 519 742-8979	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
City of Sault Ste Marie Sault Ste Marie, ON Mr. J. Sloan Tel: 705 946-9918	✓	✓				✓								✓				
Concrete Materials Lab, Dept of Engineering U. of Toronto Dr. R. D. Hooton Tel: 416 978-5912													✓					
Consoil Quality Control St. Catherines, ON Mr. J. Clunas Tel: 905 641-1162	✓	✓				✓	✓							✓	✓	✓		✓

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Construction Control Inc. Woodbridge, ON Mr. A. Davis Tel: 905 856-1438	✓	✓		✓		✓	✓							✓	✓	✓		✓
Construction Testing Asphalt Lab Oakville, ON Mr. P. Lung Tel: 905 469-6352	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Cornwall Gravel Company Limited. Cornwall, ON Mr. B. Mroz Tel: 613 932-6571	✓	✓				✓								✓				
Cox Construction Limited Guelph, ON Mr. D. Cox Tel: 519 824-6570	✓	✓				✓								✓				
Cruickshank Construction Ltd Kingston, ON Mr. B. Green Tel: 613 542-2874	✓	✓				✓								✓				
Cruickshank Construction Ltd Morrisburg, ON Mr. D. Byvelds Tel: 613 543-2978	✓	✓				✓	✓							✓				✓
D.F. Elliott Consulting Engineering New Liskeard, ON Mr. B. Gilbert Tel: 705 647-6871	✓	✓				✓	✓							✓				✓
Davroc Testing Laboratories Inc. Brampton, ON Mr. S. Fasullo Tel: 905 792-7792	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
DBA Engineering Limited Mobile 10 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓				✓
DBA Engineering Limited Mobile 3 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓				✓
DBA Engineering Limited Mobile 5 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓				✓
DBA Engineering Limited Mobile 7 Markham, ON Mr. A. Burleigh Tel: 905 940-8383	✓	✓				✓	✓							✓				✓
DBA Engineering Ltd. Kingston, ON Mr. W. McLatchie Tel: 613 389-1781	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Dibblee Construction Limited Kingston, ON Mr. C. Smith Tel: 613 389-3232	✓	✓				✓	✓							✓				
Dibblee Paving & Materials (Boyce Lab) Gloucester, ON Mr. G. Gooderham Tel: 613 829-1770	✓	✓				✓	✓							✓				

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Dibblee Paving & Materials (Moodie Lab) Nepean, ON Mr. G. Goodeham Tel: 613 829-1770	✓	✓		✓		✓	✓				✓	✓		✓				✓
District Municipality of Muskoka Bracebridge, ON Mr. D. Wood Tel: 705 645-6764	✓	✓				✓	✓							✓	✓	✓		✓
Drain Bros Excavating Ltd. Lakefield, ON Mr. D. Drain Tel: 705 639-2301	✓	✓				✓	✓				✓	✓		✓				
DST Consulting Engineers Inc. Kenora, ON Mr. J. Peterson Tel: 807 548-2383	✓	✓				✓	✓	✓						✓		✓		✓
DST Consulting Engineers Inc. Mississauga, ON Mr. Loranger Tel: 905 501-7511	✓	✓				✓								✓	✓	✓	✓	✓
DST Consulting Engineers Inc. Thunder Bay, ON Mr. B. Cenedese Tel: 807 623-2929	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
DST Consulting Engineers Inc. Ottawa, ON Mr. C. Mahoney Tel: 613 748-1415	✓	✓												✓	✓	✓		✓
Dufferin Aggregates Aberfoyle Lab – Loc. 3030, Guelph, ON Mr. J. Stewart Tel: 519 763-3499	✓	✓				✓	✓							✓				
Dufferin Aggregates Acton Quarry Acton, ON Mr. J. Stewart Tel: 519 853-2230	✓	✓				✓	✓							✓				
Dufferin Aggregates Brechin Lab – Loc. 3001, Milton, ON Mr. J. Stewart Tel: 705 484-0073	✓	✓				✓	✓							✓				
Dufferin Aggregates Millcreek Lab – Loc. 3031, Puslinch, ON Mr. J. Stewart Tel: 519 763-6991	✓	✓				✓	✓							✓				
Dufferin Aggregates Mosport Lab – Loc. 3032, Orono, ON Mr. J. Stewart Tel: 905 983-9289	✓	✓				✓	✓							✓				
Dufferin Aggregates Quality Control Lab – Loc. 3000, Milton, ON Mr. D. Stratton Tel: 416 798-4772	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓		✓		
Dufferin Brantford Lab Acton, ON Mr. J. Stewart Tel: 519 853-2230	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		
Dufferin Construction Ltd. (QC) – Bronte Lab, Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Dufferin Construction Ltd. Mobile Lab 1 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓				✓								✓				✓

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Dufferin Construction Ltd. Mobile Lab 2 Oakville, ON Mr. J. Tiwari Tel: 905 827-5750	✓	✓		✓		✓	✓				✓	✓		✓	✓	✓	✓	✓
E.C. King Contracting Lab #1 Owen Sound, ON Mr. H. Villneff Tel: 519 376-6140	✓	✓				✓	✓							✓				
Esko Savela & Son Contracting Inc. Thunder Bay, ON, Mr. E. Savela Tel: 807 983-2097	✓	✓				✓								✓				
Fermar Construction Limited Rexdale, ON, Mr. Mavritsakis Tel: 416 675-3550	✓	✓		✓		✓	✓							✓				✓
Forwell Limited Kitchener, ON Mr. B. Sugg Tel: 519 740-0612	✓	✓				✓	✓							✓				
Fowler Construction Company Bracebridge, ON Mr. T.G. Fawcett Tel: 705 645-2214	✓	✓		✓		✓	✓							✓				✓
Fowler Construction Company Mobile1 Bracebridge, ON Mr. T.G. Fawcett Tel: 705 645-2214	✓	✓		✓		✓	✓							✓				✓
G. Tackaberry & Sons Construction Co. Ltd., Athens, ON Mr. P. Rodgers Tel: 613 924-2634	✓	✓				✓	✓							✓				✓
Gamsby and Mannerow Limited Owen Sound, ON Mr. B. Dubeau Tel: 519 376-1805	✓	✓				✓								✓				✓
Gazzola Paving Ltd. Etobicoke, ON Mr. S. Andualem Tel: 416 675-7007	✓	✓		✓		✓	✓							✓				
Geo-Logic Inc. Peterborough, ON Mr. W. Rayfuse Tel: 705 749-3317	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Geo-Logic Inc. Pembroke, ON Ms. E. Reid Tel: 613 735-8361	✓	✓				✓								✓				✓
Georgian Aggregates Portable Lab Collingwood, ON Mr. M. Scot Tel: 705 445-2300	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓				
Golder Associates Ltd. London, ON Mr. W.M. Kellestine Tel: 519 471-9600	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Golder Associates Ltd. Mississauga, ON Ms. M. Manojlovic Tel: 905 567-4444		✓				✓								✓	✓	✓	✓	✓
Golder Associates Ltd. Ottawa, ON Mrs E. Kwok Tel: 613 224-5864	✓	✓		✓	✓	✓	✓							✓	✓	✓	✓	✓

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Golder Associates Ltd. Sudbury, ON Ms. K. Salvatori Lee Tel: 705 524-6861	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Golder Associates Ltd. Whitby, ON Mr. A. W. Brown Tel: 905 723-2727	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Golder Associates Ltd. Windsor, ON Mr. J.D. Rodger Tel: 519 945-5500	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Graham Brothers Brampton, ON Mr. G. Thompson Tel: 905 453-1200	✓	✓		✓		✓	✓				✓	✓		✓		✓		✓
Grant Paving & Materials (1254) New Liskeard, ON Mr. H. Villneff Tel: 705 647-4331	✓	✓				✓	✓				✓	✓		✓				✓
Grant Paving & Materials (60-889) New Liskeard, ON Mr. H. Villneff Tel: 705 647-4331	✓	✓				✓	✓							✓				✓
Grant Paving & Materials Mobile #60900 New Liskeard, ON Mr. H. Villneff Tel: 705 647-4331	✓	✓				✓	✓							✓				✓
Hacquoil Construction Limited Thunder Bay, ON Mr. G. Green Tel: 807 475-4096	✓	✓				✓								✓				
Halton Crushed Stone Limited Milton, ON Mr. G. Wilkinson Tel: 416 798-7004	✓	✓				✓	✓							✓				
Hard Rock Paving Port Colborne, ON Ms. J. Koros Tel: 905 834-4581	✓	✓				✓	✓				✓	✓		✓				✓
Harold Sutherland Construction Ltd. Kemble, ON Mr. R. Leigh Tel: 519 376-0603	✓	✓		✓		✓	✓							✓				
Holger Lohse, Consulting Geologist Mississauga, ON Mr. H. Lohse Tel: 905 812-1539								✓	✓									
Huron Construction Lab No. 1 Chatham, ON Mr. D. Smith Tel: 519 354-0170	✓	✓				✓	✓							✓				✓
Inspec-sol Inc. Kingston, ON Mr. S. Grainger Tel: 613 389-9812	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Inspec-Sol Inc. Mississauga, ON Mr. K. Roechner Tel: 905 712-4771	✓	✓				✓								✓	✓	✓		✓
Intratech Engineering Laboratories Inc. Scarborough, ON Mr. S. Dattani Tel: 416 754-2077	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
J & P Leveque Bros. Ltd. Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓		✓		✓
J & P Leveque Bros. Ltd. Mobile 1 Bancroft, ON Mr. W. Linnen Tel: 613 332-5533	✓	✓				✓	✓				✓	✓		✓		✓		✓
Jacques Whitford Limited Ottawa, ON Mr. A. Raymon Hache Tel: 613 738-0708	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Jacques Whitford Limited Markham. ON Mr. I. Patel Tel: 416 495-8614	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Jacques Whitford Limited Mobile Lab Ottawa, ON Mr. A. Raymon Hache Tel: 613 738-0708	✓	✓				✓								✓				✓
John D. Paterson & Associates Nepean, ON Mr. C. Pelletier Tel: 613 226-7381	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
John D. Patterson & Associates North Bay, ON Mr. S. Walker Tel: 707 472-5331	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓				✓
John Emery Geotechnical Engineering Limited Etobicoke, ON Mr. M. MacKay Tel: 416 213-1060	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
John Emery Geotechnical Engineering Mobile 4 Chatham, ON Mr. D. Soanes Tel: 416 213-1060	✓	✓				✓	✓							✓				✓
John Emery Geotechnical Engineering Mobile 6 Toronto, ON Mr. D. Soanes Tel: 416 213-1060	✓	✓				✓	✓							✓				✓
K.J. Beamish Construction King City, ON Mr. F. Magisano Tel: 905 833-4666	✓	✓		✓		✓	✓	✓			✓	✓		✓		✓		✓
K.J. Beamish Construction Mobile 1 King City, ON Mr. F. Magisano Tel: 905 833-4666	✓	✓				✓	✓							✓				✓
Karson Kartage & Konstruction Stittsville, ON Mr. C. MacDonald Tel: 613 831-0717	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓				
Laboratoire de Beton Ltee Montreal, QUE, Mr. M. Chatillon Tel: 514 255-0613	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓			✓				✓
Lafarge Canada Montreal, QUE, Ms. M. de Grosbois Tel:													✓					

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Lafarge Canada – Orillia Lab Brechin, ON Ms. C. Hutchinson Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada Brechin Plant Brechin, ON Ms. C. Hutchinson Tel: 705 484-5225	✓	✓		✓		✓	✓							✓				
Lafarge Canada Coldwater Plant Brechin, ON Ms. C. Hutchinson Tel: 705 484-5225	✓	✓				✓	✓							✓				
Lafarge Canada Inc. Stouffville, ON Mr. M. Hicks Tel: 905 640-7092	✓	✓		✓		✓	✓							✓				✓
Lafarge Canada Inc. – Fonthill Lab Fonthill, ON Mr. V. Forbes Tel: 519 853-2230	✓	✓				✓								✓				
Lafarge Canada Inc. – Hamilton Lab Hamilton, ON Mr. E. Clarkson Tel: 905 522-7735 x247	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Lafarge Canada Inc. – Ottawa Ottawa, ON Mr. F. Douglas Tel: 613 837-4223	✓	✓				✓	✓				✓	✓		✓				
Lafarge Canada Limited Caledon, ON Mr. M. koch Tel: 519 927-1113	✓	✓				✓	✓							✓				
Lafarge Construction Materials Ltd. Brockville, ON Mr. P. Arkeveld Tel: 613 342-0262	✓	✓				✓	✓			✓	✓	✓		✓				
Lafarge Materials & Construction, Mobile C-2, Sault Ste. Marie, ON Mr. W. Triskle Tel: 807 345-2338	✓	✓				✓	✓							✓				✓
Lafarge Materials & Construction Sault Ste. Marie, ON Mr. W. Triskle Tel: 705 759-0600	✓	✓		✓		✓	✓			✓	✓	✓		✓				✓
Lafarge Materials & Construction Thunder Bay, ON Mr. W. Triskle Tel: 807 345-2338	✓	✓				✓	✓							✓				✓
Lafarge Materials & Construction, Hanmer, Sault Ste. Marie, ON Mr. W. Triskle Tel: 705 969-4461	✓	✓				✓								✓				✓
Lafarge Materials & Construction – Kenora C-1), Kenora, ON Mr. W. Triskle Tel: 807 548-4191	✓	✓				✓								✓				✓
Lafarge Materials & Construction - Mobile C-3,Sault Ste. Marie, ON Mr. W. Triskle Tel: 705 759-0600	✓	✓				✓								✓				✓
Lafarge Quaries – Dundas Lab Dundas, ON Mr. S. Peace Tel: 905 527-3671	✓	✓		✓		✓	✓			✓	✓	✓		✓				

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Landtek Limited Hamilton, ON Mr. P. Anderson Tel: 905 383-3733	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Lavis Contracting Co. Limited Clinton, ON Mr. A. Gardner Tel: 519 482-3694	✓	✓				✓								✓				
Law Engineering (London) Inc. London, ON Mr. J. Law Tel: 519 680-9991	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Leo Alarie & Son Ltd. Timmins, ON Mr. J. Luthe Tel: 705 268-2106	✓	✓				✓	✓							✓				
M & A Associates Limited Scarborough, ON Mr. P. Balendran Tel: 416 757-8882	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
M.J. Labelle Co. Ltd. Mobile 1 Cochrane, ON Mr. G. Guppy Tel: 705 272-4201	✓	✓				✓								✓				✓
M.J. Labelle Co. Ltd. Mobile 2 Cochrane, ON Mr. G. Guppy Tel: 705 272-4201	✓	✓				✓								✓				✓
M.R. Wright & Associates Sault Ste. Marie, ON Mr. R. Wilson Tel: 705 945-5091	✓	✓		✓		✓	✓				✓	✓		✓	✓			✓
Mark Smereczynsky Petrographic Services Etobicoke, ON Mr.M.Smereczynsky Tel: 416 626-3505								✓										
McAsphalt Engineering Services Scarborough, ON Mr. K. Davidson Tel: 416 281-8181	✓	✓						✓						✓				
Merlex Engineering Ltd. North Bay, ON Mr. M. Merleau Tel: 705 476-2550	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Mill-Am Corporation Lab #890901 Windsor, ON Mr. A. Saifan Tel: 519 945-7441	✓	✓				✓	✓							✓				✓
Miller Paving Ltd. (1084) Timmins, ON Mr. H. Villneff Tel: 705 267-1107	✓	✓				✓	✓							✓				✓
Miller Northwestern Limited – 87526 Dryden, ON Mr. H. Villneff Tel: 807 223-2804	✓	✓				✓	✓							✓				✓
Miller Northwestern Limited – Mobile 2 – 87615, Dryden, ON Mr. H. Villneff Tel: 807 223-2804	✓	✓				✓	✓							✓				✓

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Miller Paving Ltd. (Markham Lab) Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓		✓		✓
Miller Paving Ltd. Carden Quarry Lab Markham, ON Mr. N. Hanasoge Tel: 905 475-6660	✓	✓				✓	✓							✓				
Miller Paving Ltd. North Bay (#8661) North Bay, ON Mr. H. Villneff Tel: 705 472-3312	✓	✓				✓	✓							✓				✓
Miller Paving Ltd. Whitby Lab Markham, ON Mr. N. Hanasoge Tel: 705 484-0195	✓	✓		✓		✓	✓							✓				✓
Ministry of Transportation Downsview, ON Mr. C. Rogers Tel: 416 235-3734	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mulder Construction & Materials Limited, Unit # 7004, West St. Paul, MB Mr. D. Walker Tel: 204 958-7400	✓	✓				✓								✓				
Mulder Construction & Materials Limited, Unit # 7005, West St. Paul, MB Mr. D. Walker Tel: 204 958-7400	✓	✓				✓								✓				
National Testing Laboratories Ltd. Winnipeg, MB Mr. D. Flatt Tel: 204 488-6999	✓	✓	✓	✓		✓								✓	✓	✓	✓	✓
Naylor Engineering Associates Ltd Kitchener, ON Ms. A. Snyder Tel: 519 741-1313	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓		✓
Nelson Aggregate Co. Paris, ON Mr. T. Sayer Tel: 519 756-0530	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Beamsville, ON Mr. T. Scambato Tel: 905 563-8226	✓	✓				✓	✓							✓				
Nelson Aggregate Co. Burlington, ON Mr. M. Rook Tel: 905 336-0453	✓	✓				✓	✓							✓				
Oliver Mangione McCalla & Associates (Trow), Nepean, ON Mr. I.M. Taki Tel: 613 225-9940	✓	✓		✓		✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓
Pedersen Construction Inc. New Liskeard, ON Mr. K. Pedersen Tel: 705 647-6223		✓				✓	✓							✓				✓
Peto MacCallum Ltd. Barrie, ON Mr. A. Jones Tel: 705 734-3900	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Ltd. Brampton, ON Mr. R. Midgley Tel: 905 796-3650	✓	✓		✓		✓	✓							✓				✓

2002 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Mark Vasavithasan (416) 235-4901, or Chris Rogers (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Peto MacCallum Ltd. Hamilton, ON Mr. E.L. Truax Tel: 905 561-2231	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Peto MacCallum Ltd. Kitchener, ON Mr. T. Smith Tel: 519 893-7500	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Peto MacCallum Ltd. Toronto, ON Mr. A. Nathoo Tel: 416 785-5110	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Peto MacCallum Ltd. Mobile 3 Toronto, ON Mr. P. Sun Tel: 416 785-5110	✓	✓		✓		✓	✓							✓				✓
Pioneer Construction Inc. (Main Lab) Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓
Pioneer Construction Inc. (Mobile 1) Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓				✓	✓							✓				✓
Pioneer Construction Inc. (Mobile 2) Sudbury, ON Mr. K. Edwards Tel: 705 560-7200	✓	✓				✓	✓							✓				✓
Precision Age Aggregate Testing Ltd. Thunder Bay, ON Mr. W. Werbowetski Tel: 807 577-3927								✓	✓									
Preston Sand and Gravel Kitchener, ON Mr. M. Bell Tel: 519 579-1248	✓	✓				✓	✓							✓				
R. W. Tomlinson Limited Gloucester, ON Mr. B. Hendriks Tel: 613 822-6884	✓	✓		✓		✓	✓			✓	✓	✓		✓		✓	✓	✓
Royel Paving Limited Mobile 1 Lindsay, ON Mr. M. Minaker Tel: 705 324-6773	✓	✓				✓	✓							✓				✓
Sarafinchin Associates Ltd. Rexdale, ON Mr. S. Jeffrey Tel: 416 674-1770	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Shaheen & Peaker Limited Etobicoke, ON Mr. A. Mendonca Tel: 416 213-1255	✓	✓				✓								✓	✓	✓	✓	✓
Shaheen & Peaker Limited (Geo-Canada) Markham, ON Mr. S. Peaker Tel: 905 474-9255	✓	✓				✓	✓							✓	✓	✓	✓	✓
Shaheen Peaker Thompson Limited Oshawa ON Mr. D. Thompson Tel: 905 436-9028	✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	✓	✓
Smelter Bay Aggregates Inc. Thessalon, ON Mr. C. Hernden Tel: 705 842-3908	✓	✓				✓	✓							✓				

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
Smith's Construction Amprior Ltd - 8660 Amprior, ON Mr. H. Villneff Tel: 613 623-3144	✓	✓				✓	✓							✓				✓
Smith's Construction Amprior Ltd - 60-853, Amprior, ON Mr. H. Villneff Tel: 613 623-3144	✓	✓				✓	✓							✓				✓
Soil Probe Limited Scarborough, ON Mr. A. Memon Tel: 416 754-7055	✓	✓		✓		✓								✓	✓	✓	✓	✓
Soil-Eng Limited Scarborough, ON Mr. S. Sanjeevan Tel: 416 754-8515	✓	✓				✓	✓							✓	✓	✓	✓	✓
Soil-Mat Limited Hamilton, ON Mr. J. Monkman Tel: 905 318-7400	✓	✓				✓	✓							✓	✓	✓	✓	✓
St Lawrence Testing & Inspection Co. Ltd Cornwall, ON Mr. G. McIntee Tel: 613 938-2521	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Steed and Evans Limited Heidelberg, ON Mr. R. Marco Tel: 519 699-4646	✓	✓				✓	✓							✓				
Strada Aggregates Concord, ON Mr. C. Tavernese Tel: 905 738-2200	✓	✓												✓				
Sutcliffe Rody Quesnel Limited New Liskeard, ON Mr. P. Seguin Tel: 705 647-4311	✓	✓				✓	✓											✓
Sutton and Associates Binbrook, ON Mr. K. MacDonald Tel: 905 692-9842	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Teranorth Construction & Engineering Limited, Sudbury, ON Mr. E. Carriere Tel: 705 523-1540	✓	✓				✓	✓							✓				✓
Terraprobe Limited Brampton, ON Mr. K. Buth Tel: 905 796-2650	✓	✓		✓		✓	✓	✓						✓	✓	✓	✓	✓
Terraprobe Limited Barrie, ON Mr. B. Jackson Tel: 705 739-8355	✓	✓		✓		✓	✓							✓	✓	✓	✓	✓
Terraprobe Limited (Mountainview) Stoney Creek, ON Mr. G. Muckle Tel: 905 643-7560	✓	✓		✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Terraprobe Limited Sudbury Sudbury, ON Mr. R. Carniello Tel: 705 670-0460	✓	✓				✓								✓	✓	✓		✓
Terraspec Engineering Peterborough, ON Mr. S. Galloway Tel: 705 743-7880	✓	✓				✓		✓						✓	✓	✓	✓	✓

2002 Participants List
Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

For further information on this program, contact:

Mark Vasavithasan (416) 235-4901, or
Chris Rogers (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils	LS- 623 One Point Proctor Density
The Murray Group Moorefield, ON Mr. B. Mitchel Tel: 519 638-3077	✓	✓				✓	✓							✓				
Thomas Cavanagh Construction Ltd. Ashton, ON Mr. P. White Tel: 613 259-2670	✓	✓				✓								✓				
Thunder Bay Testing and Engineering Thunder Bay, ON Mr. R. Frenette Tel: 807 623-5278	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Thurber Engineering Limited Oakville, ON Dr. P. K. Chatterji Tel: 905 829-8666		✓				✓									✓	✓		✓
Towland (London) 1970 Limited London, ON Mr. T. Martin Tel: 519 451-2750	✓	✓				✓	✓							✓				✓
Trow Consulting Engineers Limited Brampton, ON Mr. A. Yousif Tel: 905 793-9800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trow Consulting Engineers Limited London, ON Mr. B. Chiu Tel: 519 453-1480	✓	✓				✓	✓							✓	✓	✓		✓
Trow Consulting Engineers Limited Stoney Creek, ON Mr. C. Douglas Tel: 905 664-3300	✓	✓		✓		✓	✓							✓				✓
Trow Consulting Engineers Limited Sudbury, ON Mr. R. Ferguson Tel: 705 674-9681	✓	✓		✓		✓	✓			✓	✓	✓		✓	✓	✓	✓	✓
Trow Consulting Engineers Ltd. Thunder Bay, ON Mr. C. Baumann Tel: 807 623-9495	✓	✓		✓		✓	✓			✓	✓	✓		✓		✓		✓
TRT Sand and Gravel Limited Orono, ON Mr. P. Hill Tel: 905 983-9260	✓	✓				✓	✓							✓				
Vicdom Sand and Gravel Ltd. Uxbridge, ON Mr. B. Giordano Tel: 905 649-2193	✓	✓				✓	✓							✓				
Walker Brothers Quarries Limited Thorold, ON Mr. M. Bull Tel: 905 227-1158	✓	✓		✓		✓	✓			✓	✓	✓		✓				
Warren Bitulithic Downsview, ON Mr.B.Samulewitsch Tel: 416 633-9670	✓	✓		✓		✓	✓							✓				
Warren Bitulithic Ltd Kitchener, ON Mr. R. Prince Tel: 519 696-2274	✓	✓		✓		✓	✓							✓				
Warren Paving Ltd. Cobourg, ON Mr. D. Byford Tel: 905 372-4671	✓	✓		✓		✓	✓				✓	✓		✓		✓		✓

Appendix C: Multi-Laboratory Precision Tables

Test 1	1999		2000		2001		2002		ASTM C117
WP 75 µm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	2.28	2.33	0.84	0.94	0.85	0.90	0.89	0.86	<1.5
1S	0.32	0.33	0.21	0.21	0.13	0.12	0.22	0.19	0.22
D2S	0.91	0.93	0.59	0.60	0.36	0.34	0.62	0.54	0.62
n/Outliers	195/8		197/4		169/35		192/16		

Test 8	1999		2000		2001		2002		ASTM C131	
L. L. A	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	C of V	σ^*
Mean	27.98	28.70	51.12	51.72	24.68	24.92	24.20	24.27	10-45	24.8
1S	2.08	2.65	2.53	3.08	1.54	1.26	1.68	0.87	4.5%	1.12
D2S	5.87	7.49	7.15	8.71	4.36	3.58	4.75	2.45	12.7%	3.16
n/Outliers	13/1		11/2		11/1		11/2			

Test 9	1999		2000		2001		2002		ASTM C127
BRD	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	2.656	2.655	2.616	2.616	2.686	2.684	2.671	2.670	
1S	0.010	0.010	0.007	0.010	0.008	0.007	0.008	0.007	0.013
D2S	0.028	0.028	0.020	0.028	0.022	0.020	0.023	0.020	0.038
n/Outliers	69/10		81/6		79/10		81/9		

Test 10	1999		2000		2001		2002		ASTM C127
ABS	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	0.932	0.933	1.472	1.479	1.645	1.662	0.675	0.666	< 2%
1S	0.111	0.122	0.111	0.118	0.089	0.076	0.076	0.079	0.145
D2S	0.314	0.345	0.314	0.334	0.252	0.215	0.215	0.223	0.41
n/Outliers	75/3		85/2		82/7		86/4		

Test 11	1999		2000		2001		2002		ASTM C88	
MgSO4	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	C of V	σ^*
Mean	14.4	14.1	6.7	7.1	5.0	5.1	12.5	12.8	9-20%	5.0
1S	4.4	4.6	2.3	2.2	1.9	1.9	3.0	3.2	25%	1.25
D2S	12.4	13.1	6.6	6.3	5.4	5.4	8.5	9.0	71%	3.5
n/Outliers	30/1		32/0		40/1		35/0			

Test 12	1999		2000		2001		2002		MTO Workshop
% Crush	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	58.9	59.3	84.7	84.8	60.0	59.7	70.0	70.2	50 – 75
1S	4.8	4.9	5.1	5.2	4.6	4.9	5.3	5.6	6.0
D2S	13.5	13.8	14.6	14.8	13.0	13.9	15.0	15.8	16.9
n/Outliers	191/9		190/15		177/26		186/22		

Test 13	1999		2000		2001		2002		ASTM D 4791
% F & E	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	11.2	11.3	8.8	8.6	3.3	3.5	3.4	3.1	No ASTM
1S	4.9	4.8	2.9	3.0	2.0	2.0	1.8	1.6	Precision
D2S	13.8	13.7	8.3	8.4	5.7	5.7	5.1	4.5	Statements for
n/Outliers	126/4		146/11		142/13		145/19		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 14	1999		2000		2001		2002		ASTM
PN Conc.	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	135.0	137.0	134.8	133.8	110.7	110.3	123.1	122.8	No ASTM
1S	14.8	14.8	23.1	22.1	7.5	5.9	20.2	19.1	Standard for this
D2S	41.9	41.9	65.3	62.6	21.4	16.7	57.2	54.0	Test.
n/Outliers	33/9		34/1		30/2		31/0		

Test 16	1999		2000		2001		2002		MTO LS - 618
MDA, CA	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	19.25	19.4	17.28	17.44	6.60	6.53	19.16	18.97	21
1S	1.30	1.13	0.87	0.87	0.49	0.47	0.95	0.93	1.11
D2S	3.68	3.19	2.46	2.47	1.40	1.35	2.69	2.63	3.15
n/Outliers	42/4		51/4		60/5		62/4		

Test 17	1999		2000		2001		2002		MTO LS - 614
Freeze-thaw	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	16.74	16.44	8.68	8.78	5.65	5.84	15.64	15.44	19
1S	4.26	3.81	2.27	2.32	1.53	1.47	4.41	3.93	1.7
D2S	12.05	10.78	6.44	6.57	4.33	4.17	12.48	11.13	4.9
n/Outliers	33/3		41/10		49/3		50/2		

Test 2	1999		2000		2001		2002		ASTM C136[A]
P 19.0 mm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	96.9	96.8	93.6	93.6	94.1	94.1	98.4	98.4	100 - 95
1S	0.8	0.8	0.9	0.9	1.1	1.0	0.5	0.5	0.35
D2S	2.3	2.3	2.7	2.8	3.1	2.8	1.4	1.4	1.0
n/Outliers	199/4		198/8		207/1		208/3		

Test 3	1999		2000		2001		2002		ASTM C136[A]
P 16.0 mm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	88.7	88.5	85.5	85.3	86.2	86.4	92.7	92.8	95 - 85
1S	1.1	1.4	1.1	1.3	1.3	1.2	0.9	0.9	1.37
D2S	3.1	4.0	3.3	3.8	3.7	3.4	2.7	2.5	3.9
n/Outliers	189/12		199/6		204/4		205/6		

Test 4	1999		2000		2001		2002		ASTM C136[A]
P 13.2 mm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	79.6	79.5	78.4	78.0	79.1	79.4	86.5	86.6	95 – 85
1S	1.4	1.7	1.3	1.5	1.5	1.3	1.4	1.1	1.37
D2S	4.0	4.8	3.7	4.2	4.3	3.8	3.9	3.1	3.9
n/Outliers	192/11		201/5		201/7		204/7		

Test 5	1999		2000		2001		2002		ASTM C136[A]
P 9.5 mm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	62.7	62.4	67.8	67.2	67.3	67.4	72.6	71.5	80 – 60
1S	1.2	2.2	1.3	1.5	1.5	1.3	1.9	1.6	2.82
D2S	3.4	6.1	3.6	4.3	4.2	3.9	5.4	4.4	8.0
n/Outliers	189/14		199/7		200/8		200/11		

Test 6	1999		2000		2001		2002		ASTM C136[A]
P 4.75 mm	1.99	2.99	1.00	2.00	1.01	2.01	1.02	2.02	
Mean	38.4	38.1	55.0	54.4	51.1	51.1	48.5	44.7	60 – 20
1S	1.3	2.2	1.4	1.5	1.4	1.4	2.7	2.2	1.97
D2S	3.6	6.2	4.0	4.3	4.0	3.9	7.8	6.4	5.6
n/Outliers	191/12		200/6		197/11		205/6		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	1999		2000		2001		2002		ASTM C136[A]
P 2.36 mm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	25.4	25.2	47.0	46.6	41.8	41.9	40.1	36.6	60 – 20
1S	1.5	1.9	1.4	1.6	1.5	1.6	2.8	2.5	1.41
D2S	4.2	5.4	4.0	4.6	4.3	4.5	8.0	7.2	4.0
n/Outliers	195/7		200/5		194/14		205/6		

Test 21	1999		2000		2001		2002		ASTM C136[A]
P 1.18 mm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	17.8	17.7	40.1	39.5	34.1	34.3	32.9	29.8	60 – 20
1S	1.4	1.5	1.6	1.7	1.7	1.8	2.7	2.3	1.41
D2S	3.9	4.2	4.6	4.9	4.9	5.2	7.6	6.6	4.0
n/Outliers	192/11		201/4		198/10		205/6		

Test 22	1999		2000		2001		2002		ASTM C136[A]
P 600 µm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	13.7	13.6	31.0	30.6	25.4	25.6	24.2	21.9	60 – 20
1S	1.1	1.3	1.6	1.7	1.6	1.6	2.3	1.9	1.41
D2S	3.1	3.6	4.6	4.7	4.6	4.6	6.5	5.4	4.0
n/Outliers	189/13		196/9		197/11		203/8		

Test 23	1999		2000		2001		2002		ASTM C136[A]
P 300 µm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	11.2	11.1	19.1	18.8	14.0	14.2	13.6	12.4	15 – 10
1S	0.9	1.1	1.4	1.2	0.9	0.9	1.4	1.3	0.73
D2S	2.6	3.2	4.0	3.4	2.7	2.7	4.0	3.7	2.1
n/Outliers	191/12		198/7		191/17		202/9		

Test 24	1999		2000		2001		2002		ASTM C136[A]
P 150 µm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	9.4	9.4	9.2	9.1	7.7	7.8	4.9	4.5	10 – 2
1S	0.8	1.0	0.8	0.7	0.5	0.5	0.6	0.6	0.65
D2S	2.1	2.8	2.5	2.2	1.3	1.5	1.6	1.7	1.8
n/Outliers	187/15		201/4			189/19	201/10		

Test 25	1999		2000		2001		2002		ASTM C136[A]
P 75 µm	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	8.0	8.1	4.5	4.4	5.3	5.4	1.8	1.8	2 – 0
1S	0.7	0.8	0.5	0.5	0.4	0.4	0.2	0.3	0.31
D2S	1.8	2.3	1.4	1.3	1.1	1.1	0.7	0.8	0.9
n/Outliers	187/16		201/4		193/15		204/7		

Test 27	1999		2000		2001		2002		ASTM C 128
BRD	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	2.589	2.589	2.699	2.700	2.654	2.652	2.718	2.717	
1S	0.017	0.020	0.017	0.017	0.013	0.015	0.015	0.013	0.023
D2S	0.048	0.057	0.048	0.048	0.036	0.042	0.042	0.037	0.066
n/Outliers	69/7		72/8		78/7		77/9		

Test 28	1999		2000		2001		2002		ASTM C 128
ABS	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	1.74	1.73	0.65	0.65	0.76	0.78	0.95	0.97	< 1.0%
1S	0.33	0.36	0.19	0.20	0.16	0.19	0.18	0.19	0.23
D2S	0.93	1.02	0.55	0.58	0.47	0.53	0.52	0.54	0.66
n/Outliers	70/6		76/4		78/7		81/5		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 29	1999		2000		2001		2002		ASTM C117
MgSO4	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	22.8	22.6	13.0	12.6	8.3	8.3	7.4	7.3	ASTM precision
1S	9.4	8.6	4.7	4.7	3.5	3.3	3.2	2.8	statements for
D2S	26.6	24.4	13.3	13.3	9.8	9.3	9.2	8.0	coarse
n/Outliers	25/0		27/0		33/2		31/0		aggregate only

Test 30	2001		2002		2003		2004		MTO LS-621
% ACP	1.01	2.01	1.02	2.02	1.03	2.03	1.04	2.04	
Mean	29.8	29.7	28.1	41.8					No MTO
1S	2. 8	2.9	2.7	5.4					precision
D2S	8.1	8.3	7.6	15.2					statements for
n/Outliers	190/12		202/7						this test

Test 31	1999		2000		2001		2002		MTO LS-623
MWD	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	2.332	2.331	2.371	2.374	2.248	2.249	2.146	2.153	No MTO
1S	0.030	0.029	0.039	0.037	0.028	0.026	0.028	0.030	precision
D2S	0.085	0.082	0.110	0.104	0.079	0.073	0.079	0.085	statements for
n/Outliers	104/6		125/3		127/17		130/14		this test

Test 32	1999		2000		2001		2002		MTO LS-623
MDD	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	2.163	2.160	2.214	2.214	2.066	2.066	1.941	1.949	No MTO
1S	0.032	0.035	0.034	0.033	0.028	0.029	0.032	0.032	precision
D2S	0.091	0.099	0.096	0.093	0.079	0.082	0.090	0.090	statements for
n/Outliers	106/4		121/7		129/15		133/11		this test

Test 33	1999		2000		2001		2002		MTO LS-623
OMC	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	7.83	7.87	7.36	7.41	8.89	8.88	10.63	10.53	No MTO
1S	0.42	0.43	0.30	0.30	0.51	0.55	0.52	0.54	precision
D2S	1.19	1.22	0.86	0.87	1.43	1.57	1.47	1.53	statements for
n/Outliers	107/3		117/11		133/10		136/8		this test

Test 34	1999		2000		2001		2002		MTO LS-619
MDA, FA3	3.99	4.99	3.00	4.00	3.01	4.01	3.02	4.02	
Mean	30.0	29.8	7.6	7.5	11.1	11.1	13.7	13.8	10.5
1S	3.1	3.4	1.0	1.1	0.9	0.9	1.3	1.2	0.6
D2S	8.8	9.6	3.0	3.2	2.7	2.6	3.7	3.4	1.8
n/Outliers	45/1		54/2		62/2		61/2		

Test 40	1999		2000		2001		2002		MTO LS-702
P 2.0 mm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	100.0	100.0	100.0	100.0	99.9	99.9	100.0	99.9	No MTO
1S					0.08	0.06		0.05	precision
D2S					0.25	0.17		0.13	statements for
n/Outliers	69/0		55/8		69/18		60/16		this test

Test 41	1999		2000		2001		2002		MTO LS-702
P 425 µm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	96.5	96.8	98.5	98.4	96.3	96.3	98.3	96.3	No MTO
1S	0.9	0.9	0.5	0.5	0.3	0.5	0.5	0.5	precision
D2S	2.5	2.5	1.4	1.5	0.9	1.5	1.4	1.3	statements for
n/Outliers	64/6		59/4		65/22		60/15		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 42	1999		2000		2001		2002		MTO LS-702
P 75 µm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	90.7	90.8	92.7	92.6	88.6	88.7	92.5	88.6	No MTO
1S	0.9	0.9	0.8	0.7	0.5	0.5	0.7	0.4	precision
D2S	2.5	2.5	2.3	2.2	1.4	1.4	2.1	1.1	statements for
n/Outliers	61/9		56/7		62/25		58/17		this test

Test 43	1999		2000		2001		2002		MTO LS-702
P 20 µm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	77.5	77.5	62.6	62.7	69.6	69.8	63.5	70.2	No MTO
1S	4.0	3.9	4.5	5.1	4.0	3.8	3.8	4.0	precision
D2S	11.4	11.1	12.8	14.5	11.4	10.7	10.7	11.5	statements for
n/Outliers	65/4		60/3		68/19		66/9		this test

Test 44	1999		2000		2001		2002		MTO LS-702
P 5 µm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	56.1	56.7	45.3	45.4	43.8	44.0	45.0	44.7	No MTO
1S	3.2	3.2	4.8	5.0	3.2	2.9	3.5	3.0	precision
D2S	9.0	9.0	13.6	14.3	9.1	8.2	10.0	8.6	statements for
n/Outliers	60/9		61/2		66/21		66/9		this test

Test 45	1999		2000		2001		2002		MTO LS-702
P 2 µm	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	41.5	41.6	34.6	34.7	30.9	30.9	33.4	31.1	No MTO
1S	3.1	2.9	3.9	4.4	2.7	2.9	3.7	3.4	precision
D2S	8.8	8.3	11.1	12.5	7.6	8.2	10.6	9.5	statements for
n/Outliers	57/11		59/4		66/21		67/8		this test
Test 46	1999		2000		2001		2002		ASTM D 4318
L. L	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	36.9	36.9	34.6	34.6	27.3	27.3	34.1	27.4	33.3
1S	1.59	1.62	2.00	1.93	1.18	1.18	2.8	1.6	0.8
D2S	4.49	4.59	5.66	5.46	3.34	3.36	7.92	4.47	2
n/Outliers	68/9		74/0		74/7		73/5		

Test 47	1999		2000		2001		2002		ASTM D 4318
P. L	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	18.8	19.1	17.6	17.8	15.3	15.4	17.8	15.5	19.9
1S	1.87	1.66	1.76	1.75	1.01	0.98	1.65	1.24	1.3
D2S	5.29	4.70	5.00	4.94	2.86	2.78	4.68	3.52	4
n/Outliers	73/4		74/0		76/5		72/6		
Test 48	1999		2000		2001		2002		ASTM D 4318
P. I	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	17.8	17.5	16.8	16.6	12.2	12.1	16.2	11.9	13.4
1S	2.19	2.38	2.26	2.33	1.69	1.74	2.93	1.42	1.6
D2S	6.22	6.72	6.39	6.60	4.79	4.92	8.30	4.01	4
n/Outliers	72/5		73/1		79/2		73/5		

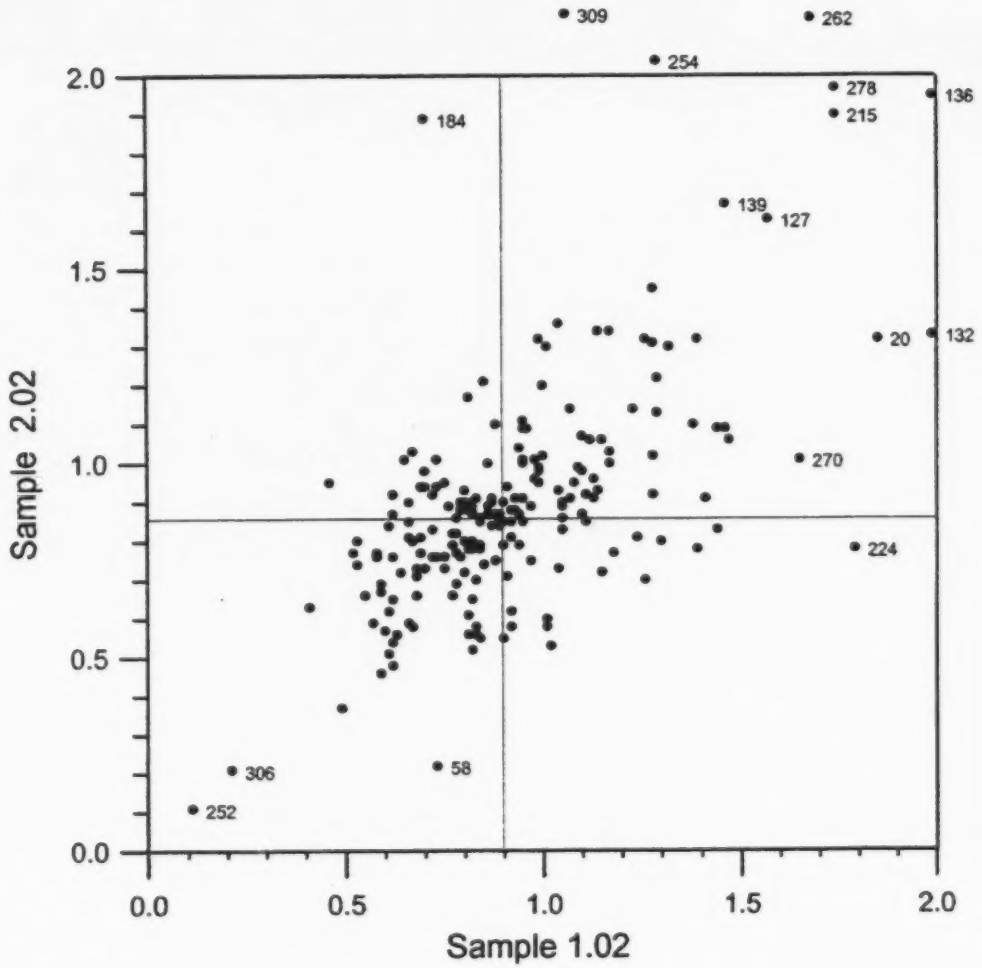
Test 49	1999		2000		2001		2002		ASTM D 854
SG of Soils	5.99	6.99	5.00	6.00	5.01	6.01	5.02	6.02	
Mean	2.705	2.704	2.689	2.691	2.720	2.725	2.713	2.732	
1S	0.041	0.040	0.057	0.054	0.026	0.025	0.035	0.026	0.041
D2S	0.116	0.113	0.161	0.152	0.073	0.071	0.099	0.073	0.12
n/Outliers	44/0		42/1		55/8		56/9		

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D: Scatter Diagrams

2002 MTO AGGREGATE AND SOIL
PROFICIENCY SAMPLE TESTING PROGRAM

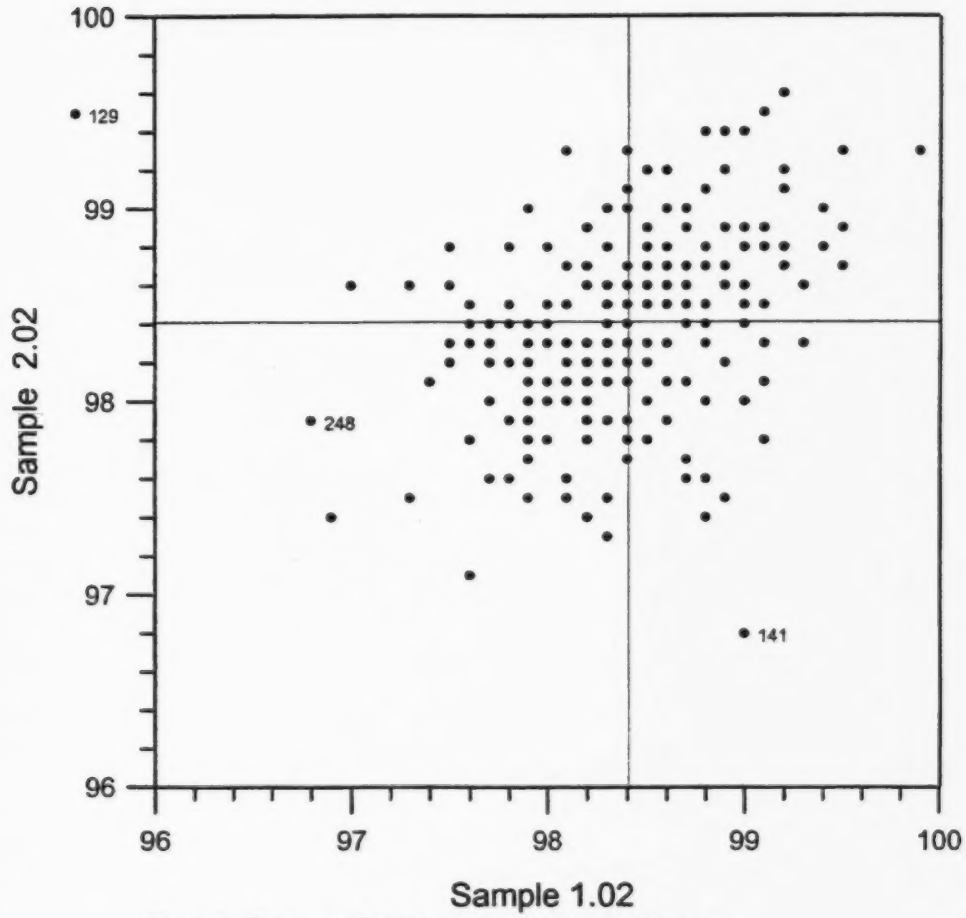


Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	0.894	0.865
Median	0.865	0.865
Std Dev	0.222	0.194
n = 192		

Labs Eliminated: 20, 58, 127, 132, 136, 139, 184, 215, 224, 252, 254, 262, 270, 278, 306, 309

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

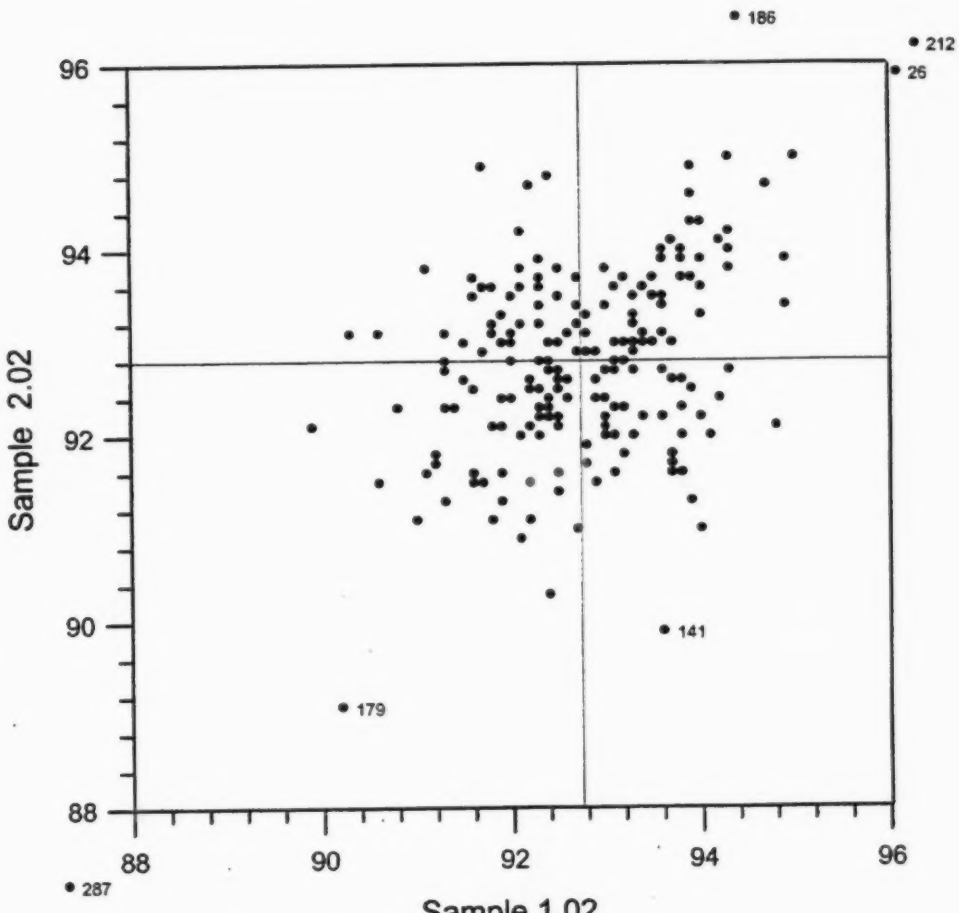


Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	98.402	98.401
Median	98.400	98.400
Std Dev	0.505	0.478
n = 208		

Lab Eliminated: 121, 141, 248

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

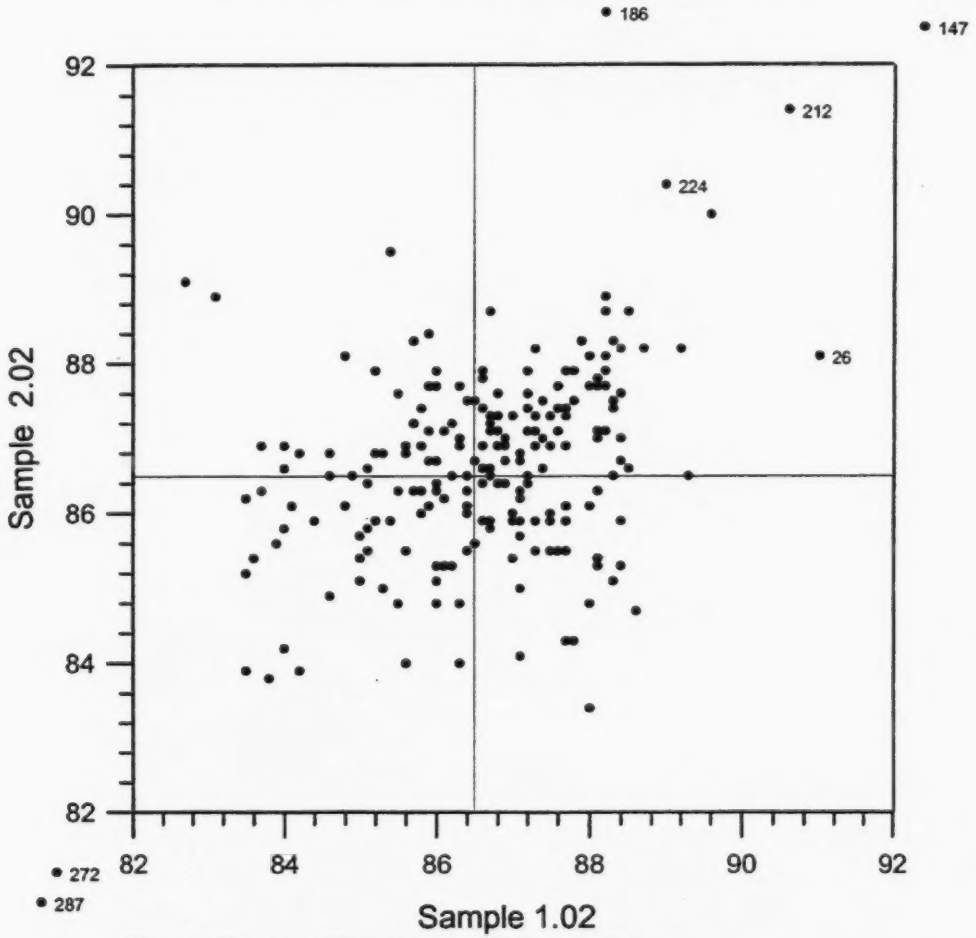


Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	92.752	92.801
Median	92.800	92.800
Std Dev	0.947	0.879
n = 205		

Labs Eliminated: 26, 141, 179, 186, 212, 287

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

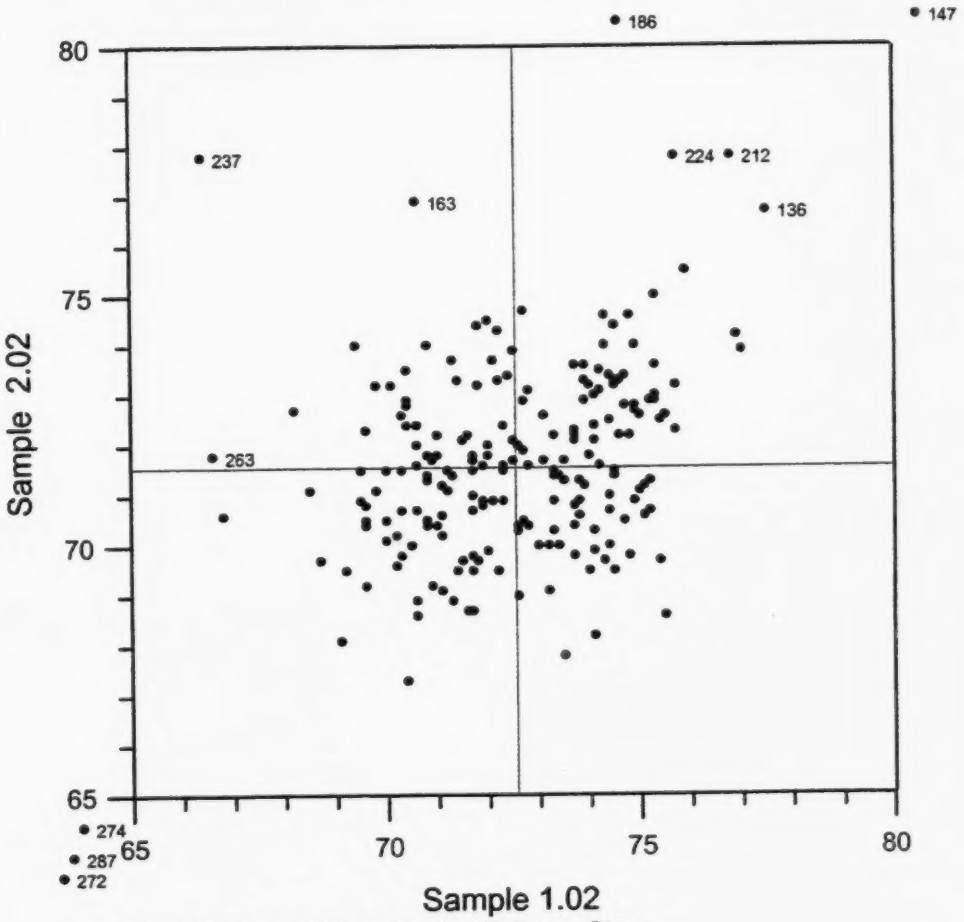


Test 4: Percent Passing the 13.2 mm Sieve

	Mat 1	Mat 2
Mean	86.566	86.575
Median	86.700	86.600
Std Dev	1.361	1.149
n = 204		

Labs Eliminated: 26, 147, 186, 212, 224, 272, 287

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

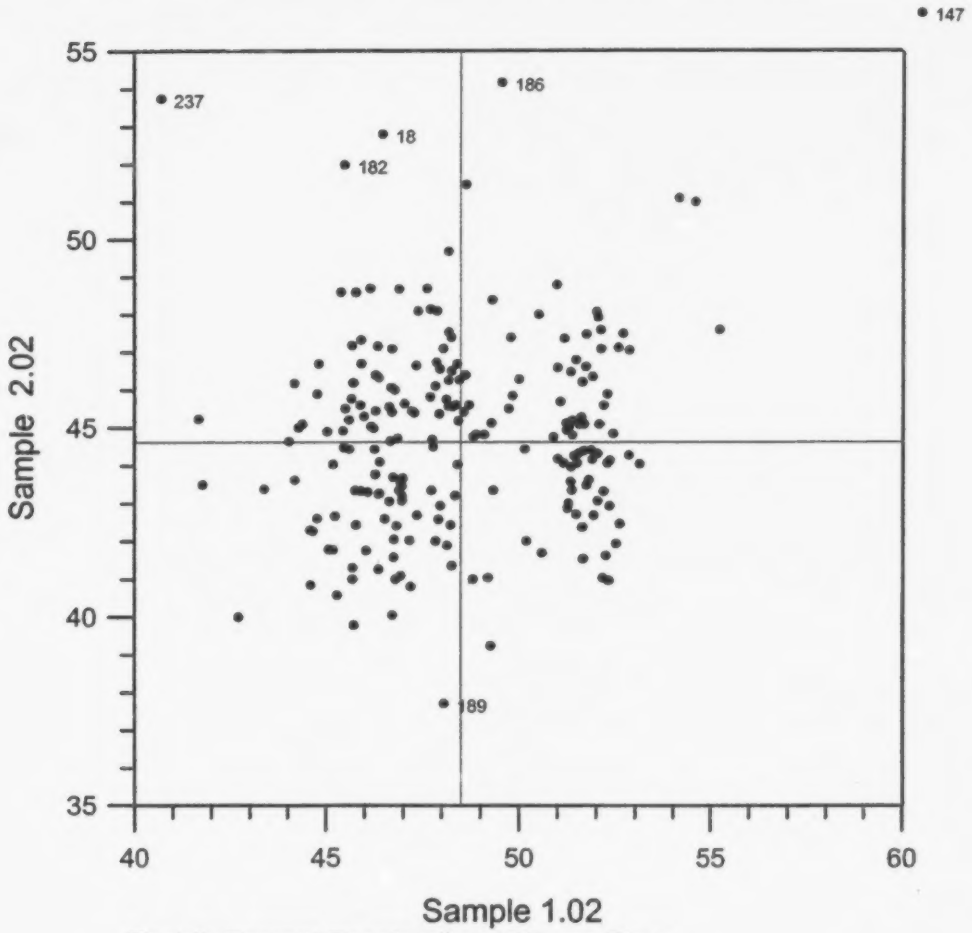


Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	72.581	71.554
Median	72.600	71.500
Std Dev	1.916	1.575
n = 200		

Labs Eliminated: 136, 147, 163, 186, 212, 224, 237, 263, 272, 274, 287

2002MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

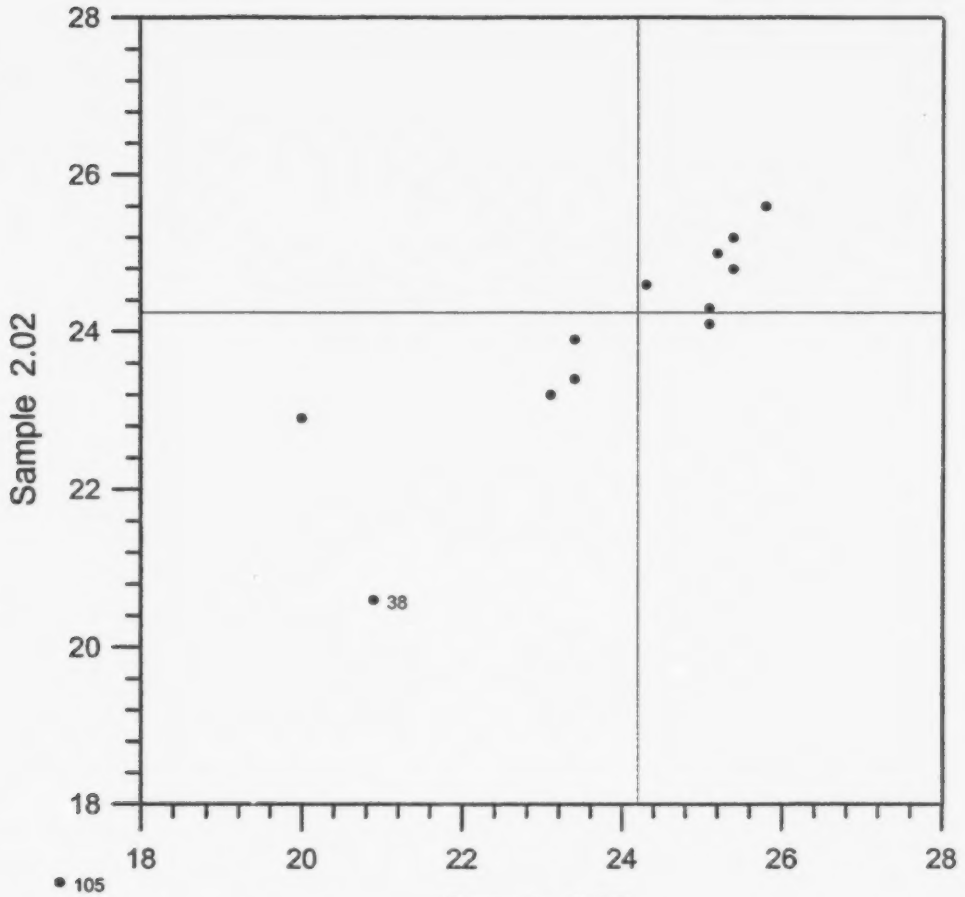


Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	48.518	44.688
Median	48.140	44.810
Std Dev	2.756	2.263
n = 205		

Labs Eliminated: 18, 147, 182, 186, 189, 237

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

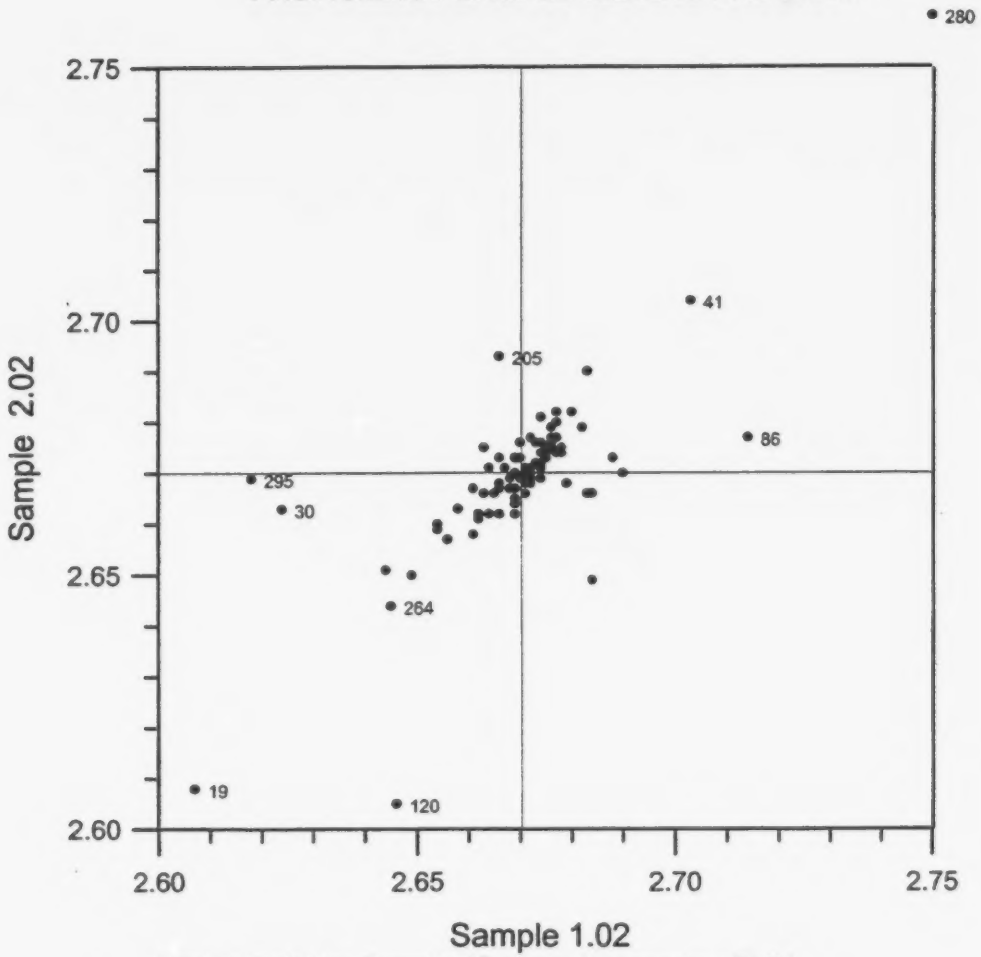


Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	24.200	24.273
Median	25.100	24.300
Std Dev	1.679	0.866
n = 11		

Labs Eliminated: 38, 105

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

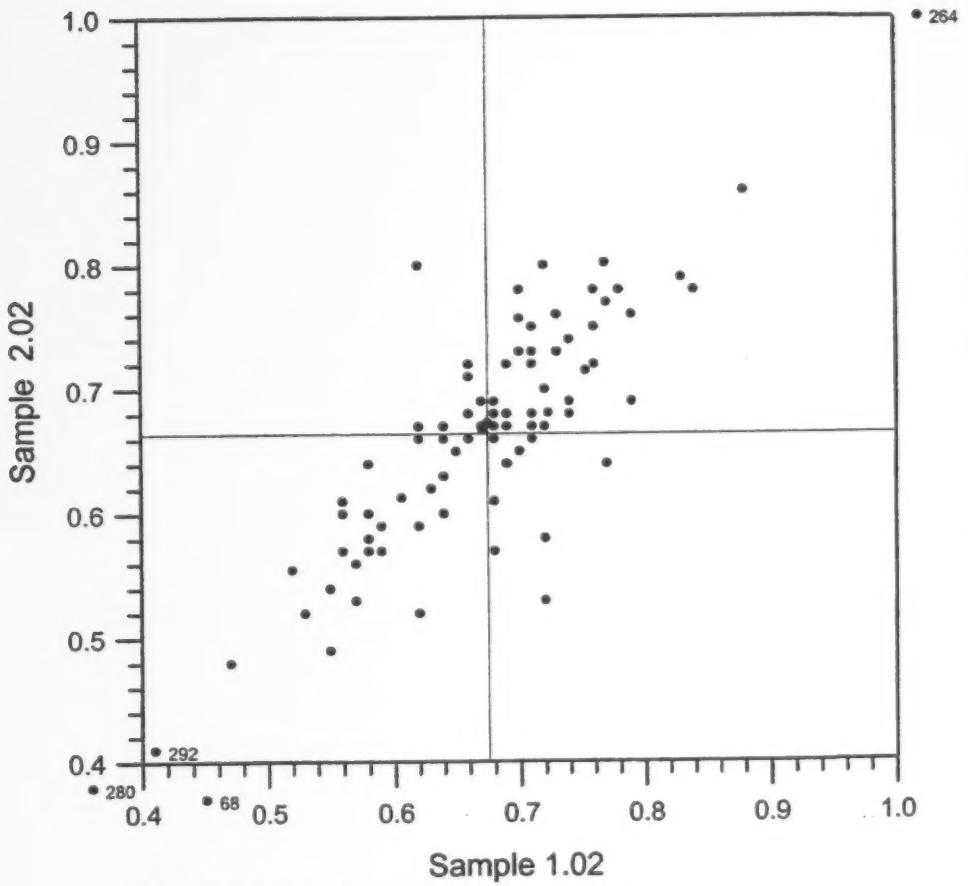


Test 9: Relative Density (Coarse Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.671	2.670
Median	2.671	2.670
Std Dev	0.008	0.007
n = 81		

Labs Eliminated: 19, 30, 41, 86, 120, 205, 264, 280, 295

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

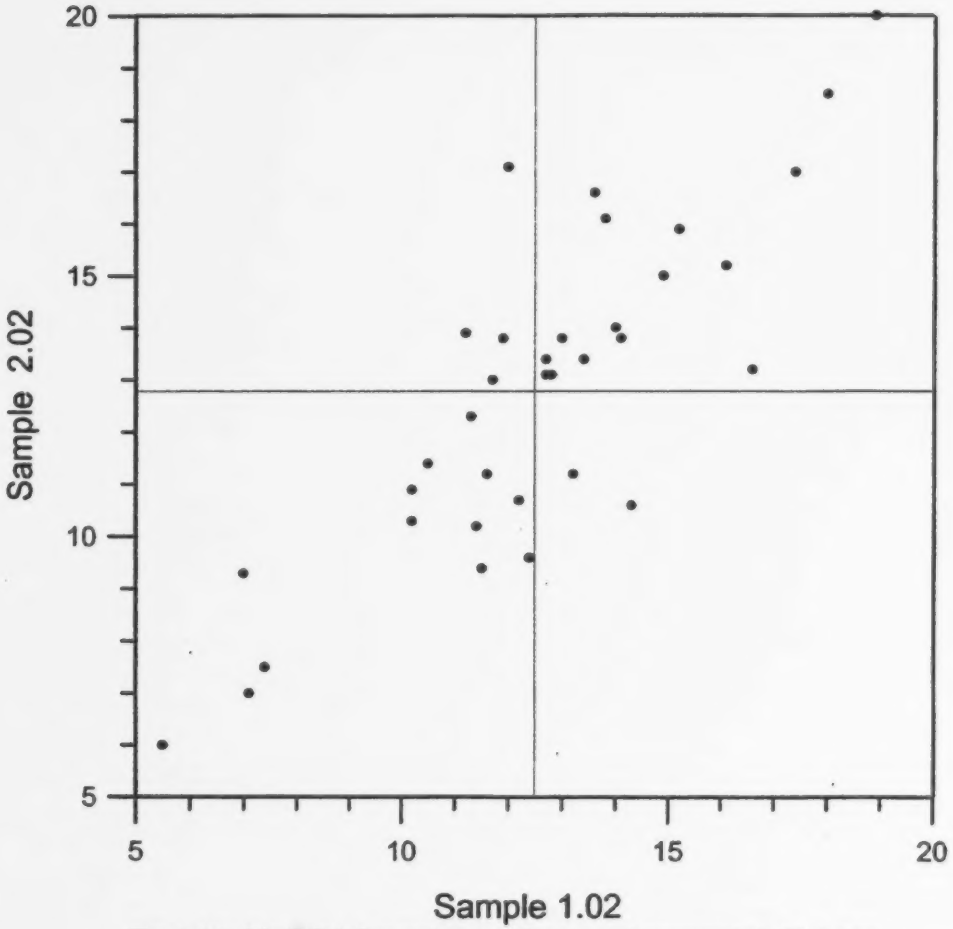


Test 10: Absorption (Coarse Aggregate)

	Mat 1	Mat 2
Mean	0.675	0.666
Median	0.680	0.670
Std Dev	0.076	0.079
n = 86		

Labs Eliminated: 68, 264, 280, 292

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

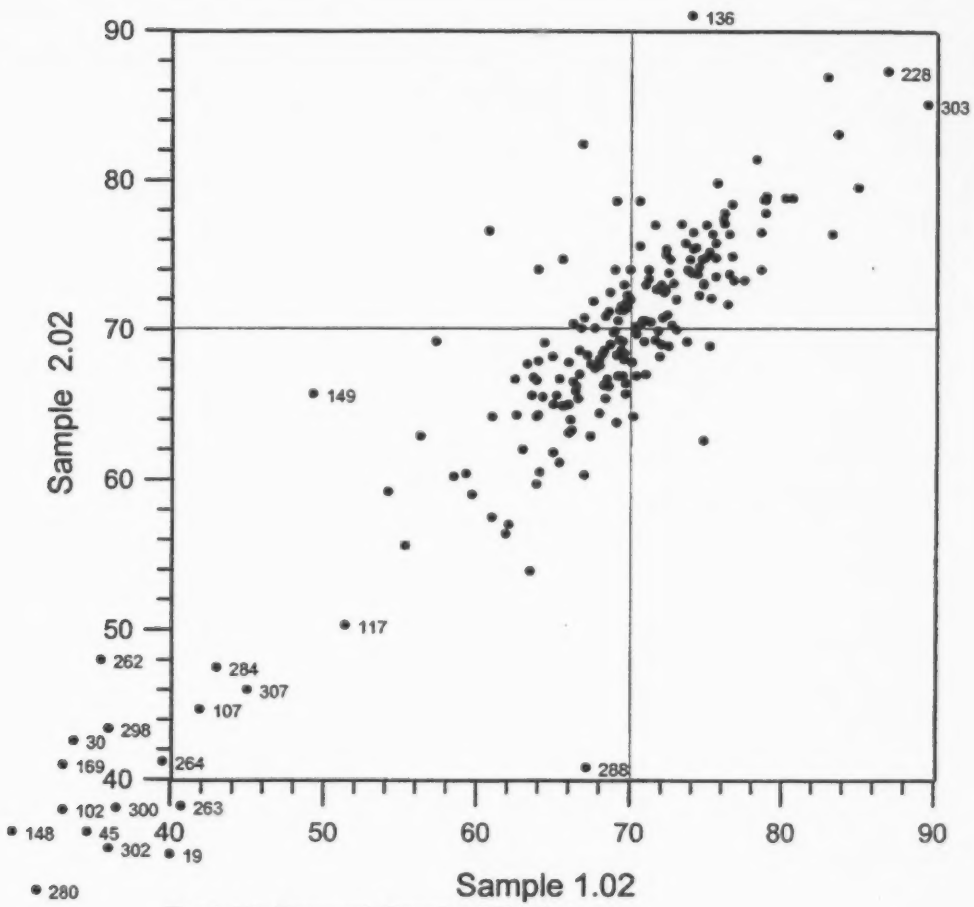


Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	12.566	12.786
Median	12.700	13.100
Std Dev	3.005	3.199
n = 35		

Lab Eliminated: None

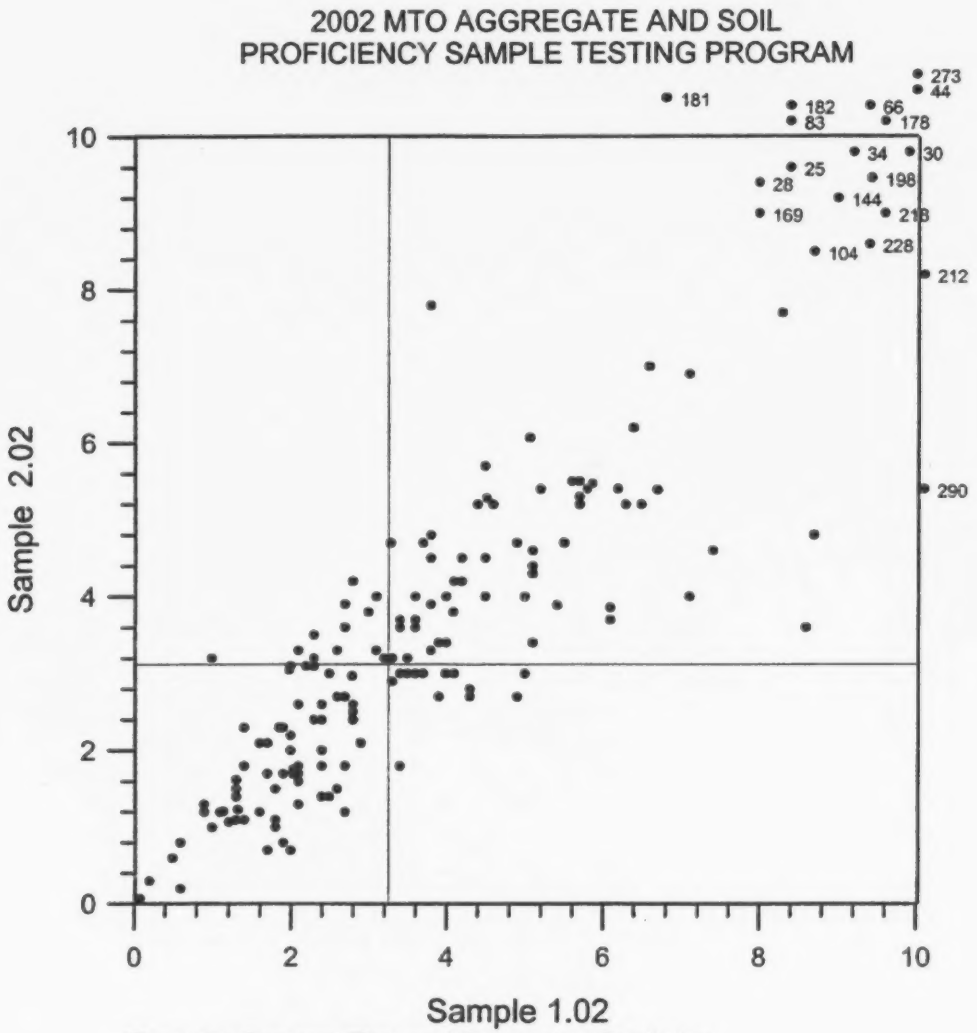
2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	69.998	70.208
Median	69.750	70.350
Std Dev	5.356	5.607
n = 186		

Labs Eliminated: 19, 30, 45, 102, 107, 117, 136, 148, 149, 169, 228, 262, 263, 264, 280, 284, 288, 298, 300, 302, 303, 307

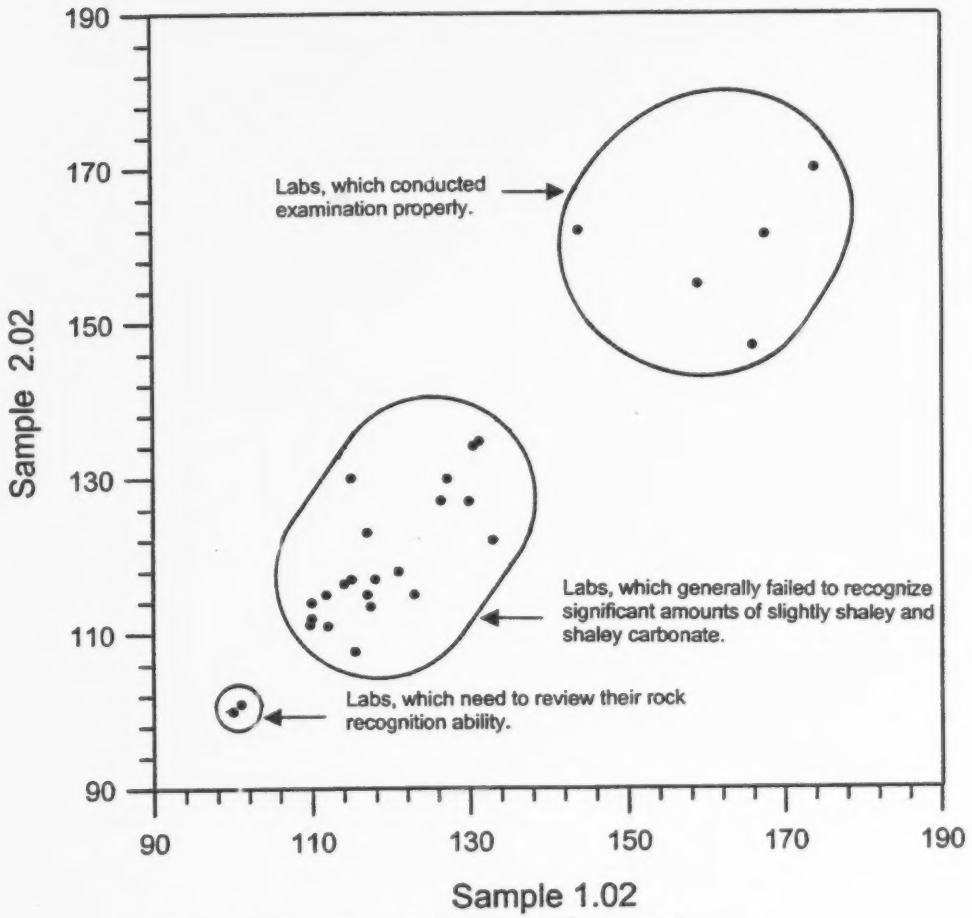


Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	3.366	3.140
Median	3.100	3.050
Std Dev	1.806	1.602
n = 145		

Labs Eliminated: 25, 28, 30, 34, 44, 66, 83, 104, 144, 169, 178, 181, 182, 198, 212, 218, 228, 273, 290

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

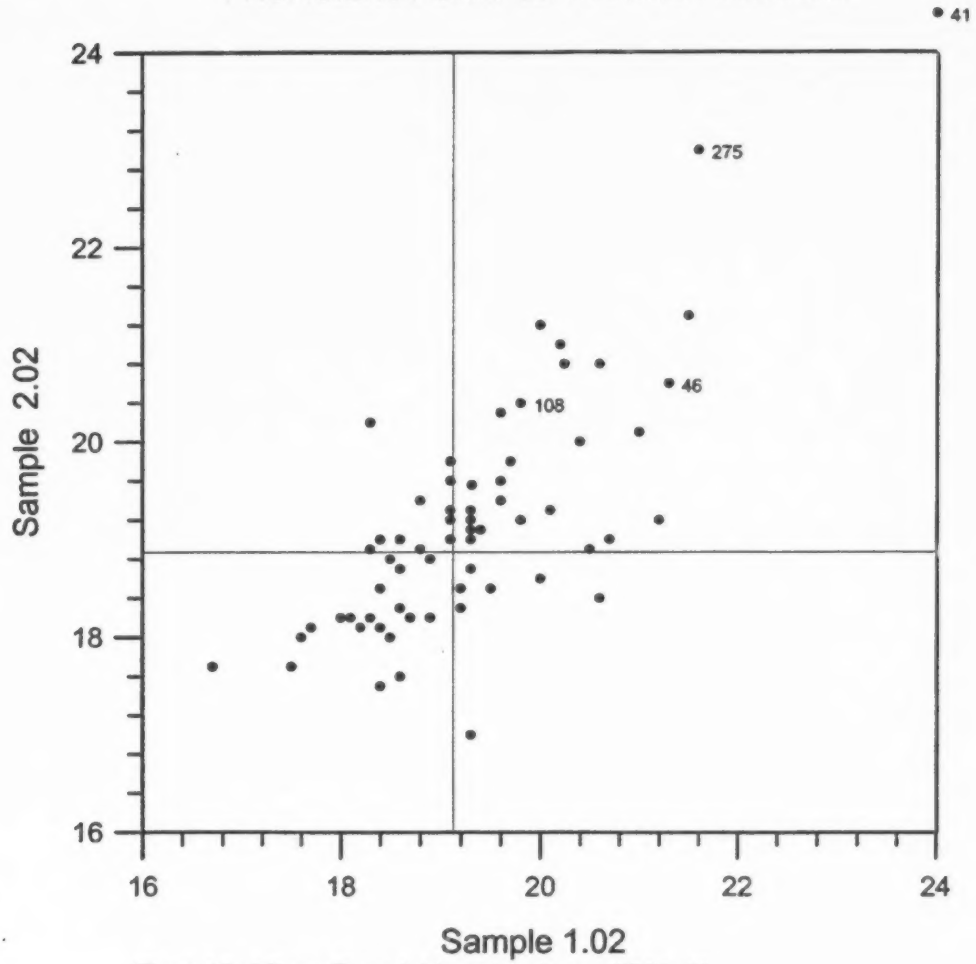


Test 14: Petrographic Number (Concrete)

	Mat 1	Mat 2
Mean	123.123	110.310
Median	117.000	117.000
Std Dev	20.197	19.093
n = 31		

Lab Eliminated: None

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

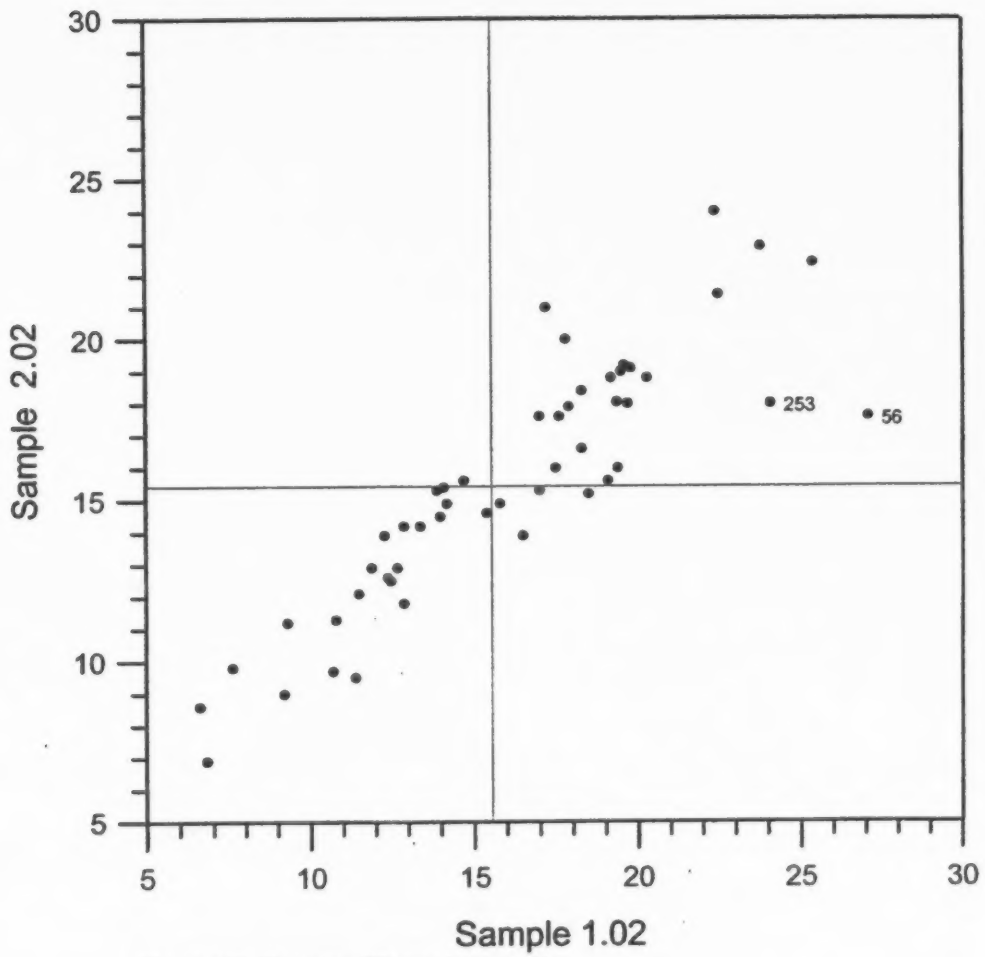


Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	19.163	18.976
Median	19.150	19.000
Std Dev	0.950	0.933
n = 62		

Labs eliminated by analysis: 41, 275

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

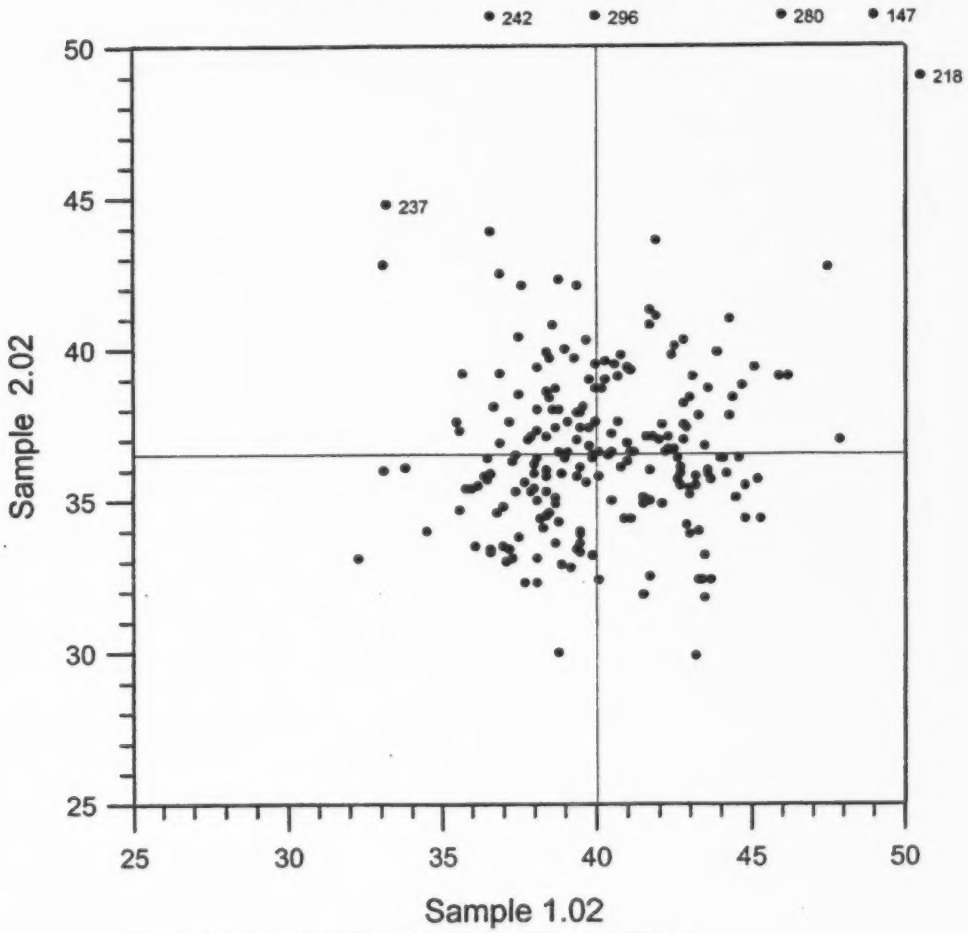


Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	15.639	15.439
Median	16.750	15.350
Std Dev	4.410	3.934
n = 50		

Labs eliminated by analysis: None

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

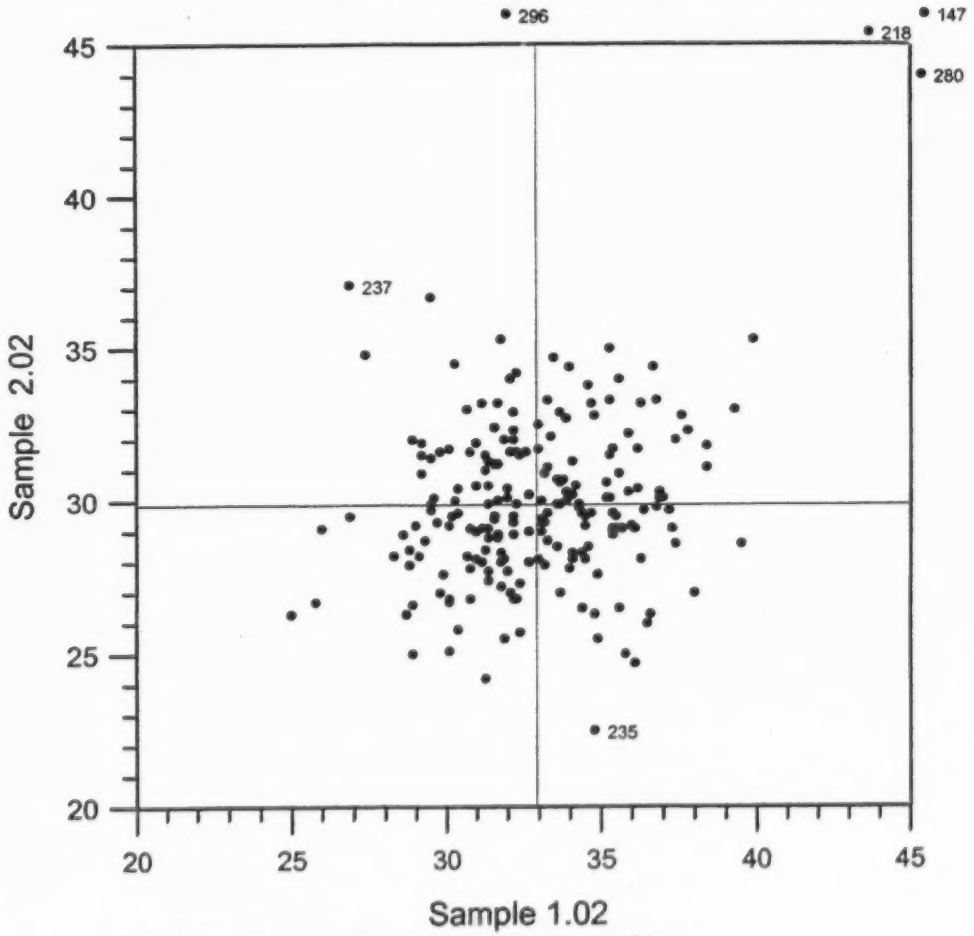


Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	40.126	36.577
Median	39.800	36.400
Std Dev	2.844	2.541
n = 205		

Labs Eliminated: 147, 218, 237, 242, 280, 296

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

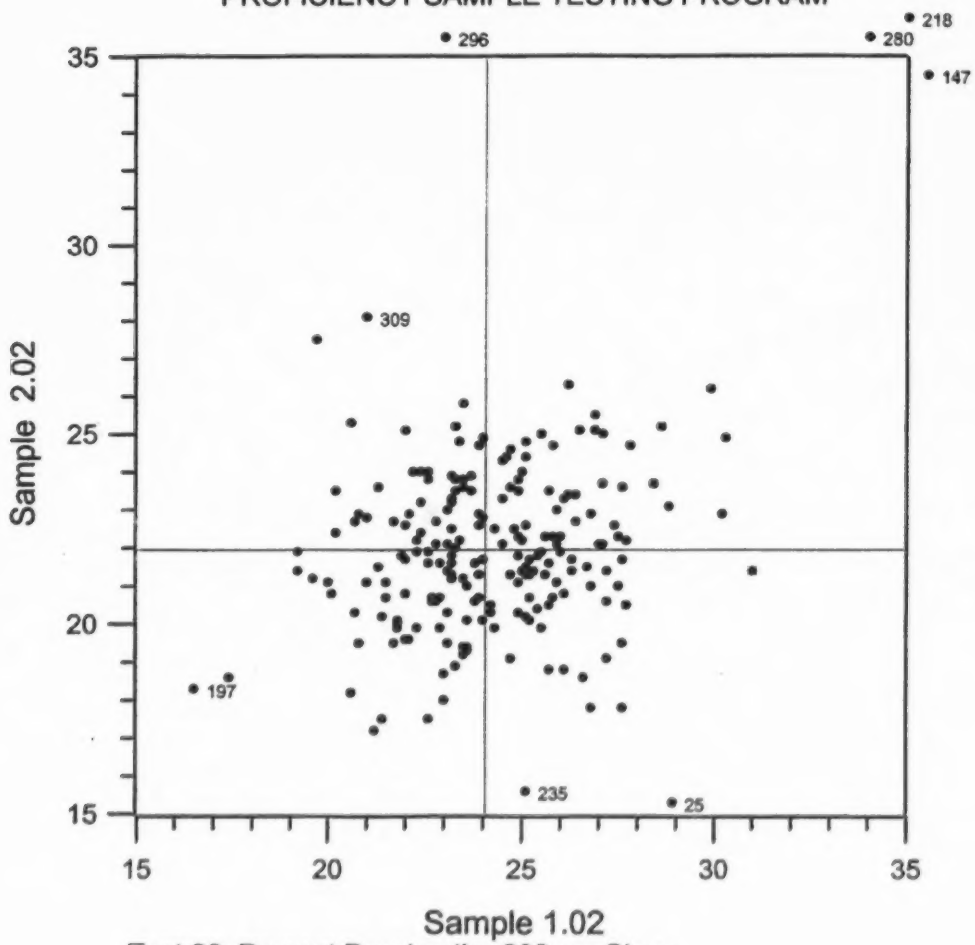


Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	32.907	29.846
Median	32.700	29.600
Std Dev	2.709	2.331
n = 205		

Labs Eliminated: 147, 218, 235, 237, 280, 296

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

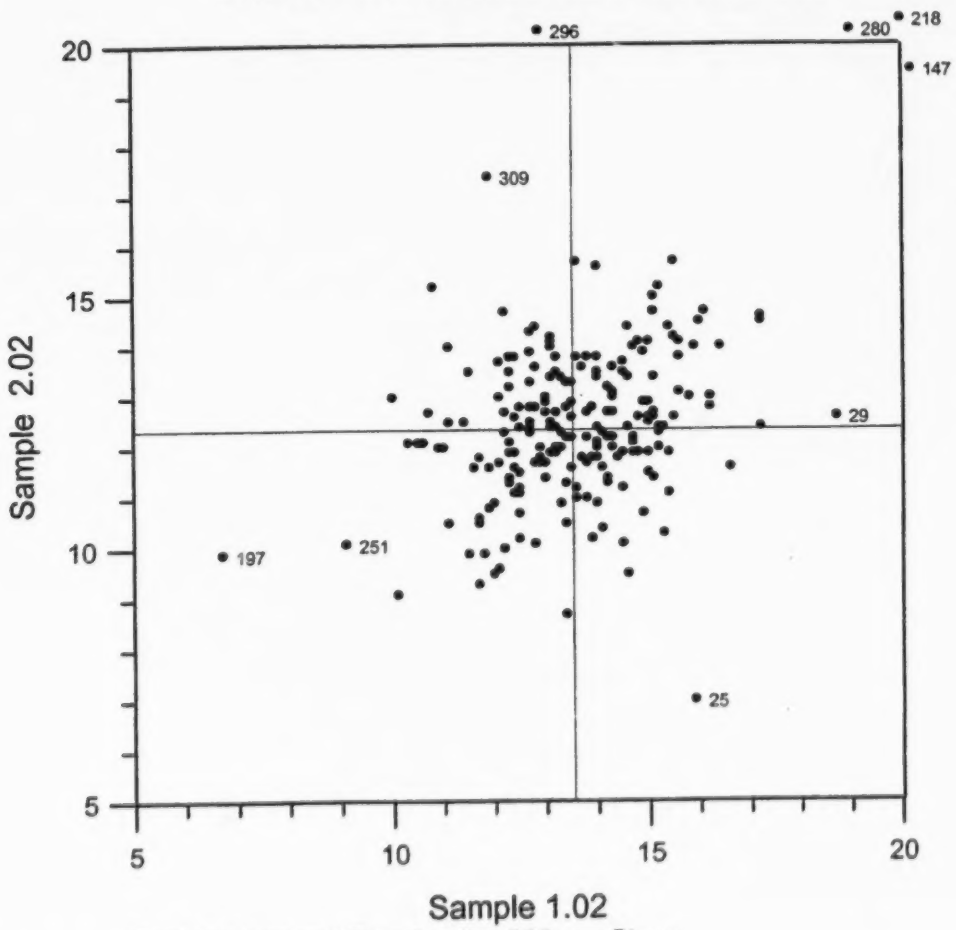


Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	24.194	21.887
Median	23.900	21.800
Std Dev	2.306	1.902
n = 203		

Labs Eliminated: 25, 147, 197, 218, 235, 280, 296, 309

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

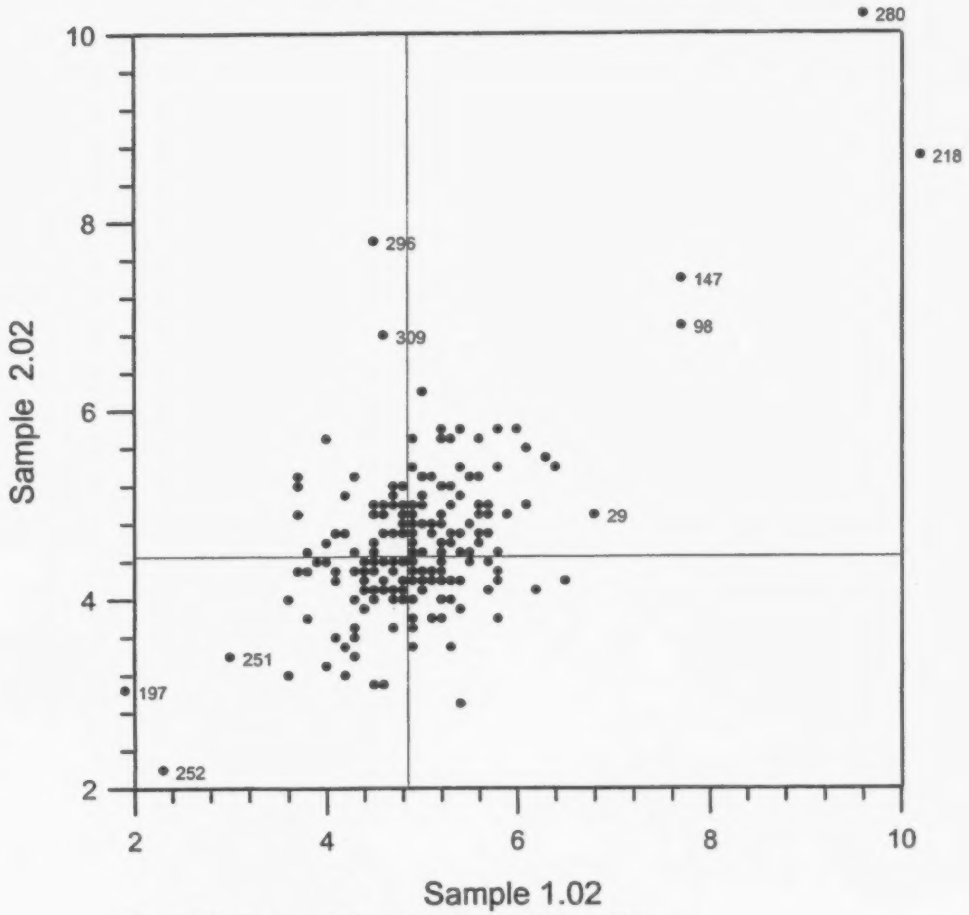


Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	13.580	12.430
Median	13.550	12.400
Std Dev	1.427	1.322
n = 202		

Labs Eliminated: 25, 29, 147, 197, 218, 251, 280, 296, 309

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

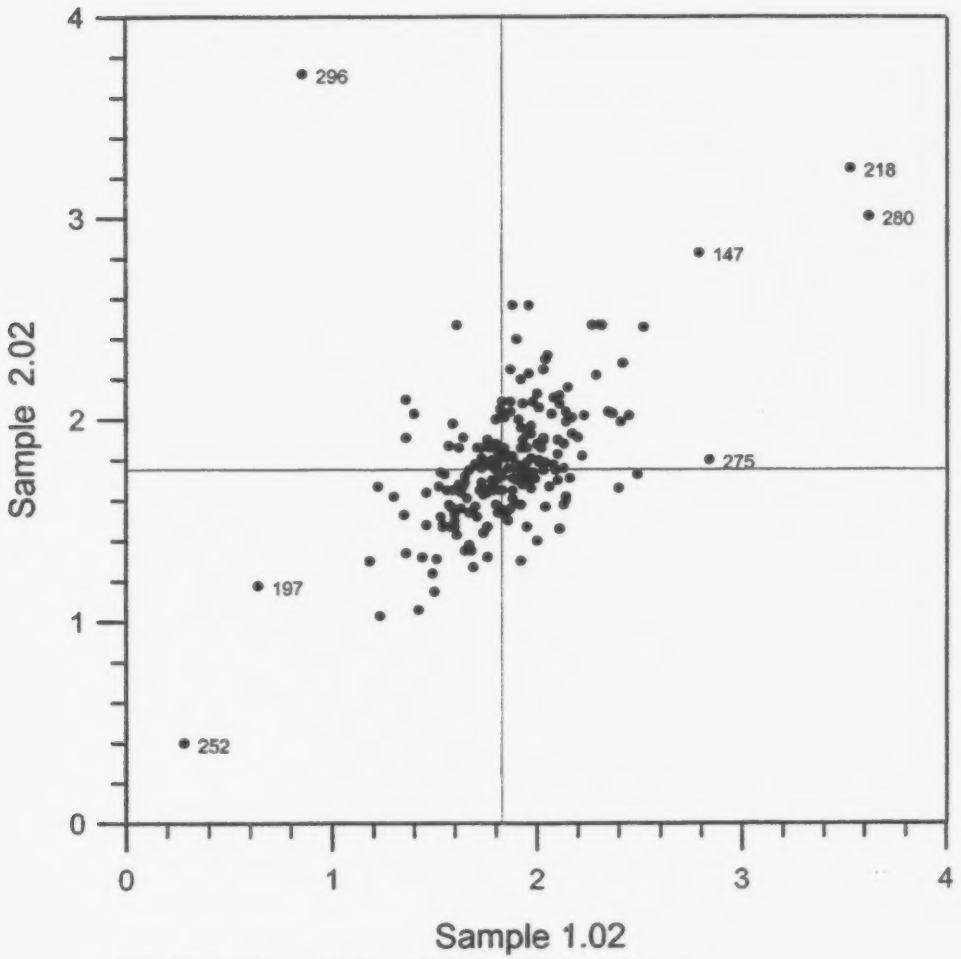


Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	4.901	4.549
Median	4.900	4.500
Std Dev	0.574	0.592
n = 201		

Labs Eliminated: 29, 98, 147, 197, 218, 251, 252, 280, 296, 309

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

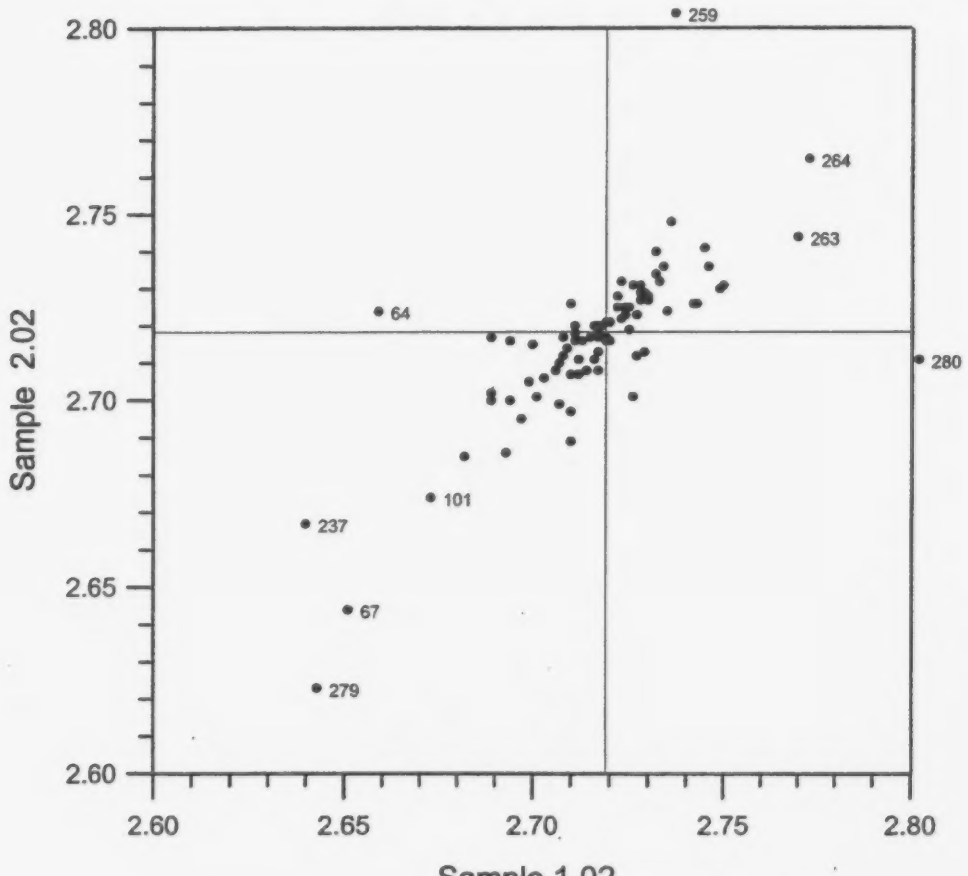


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	1.852	1.779
Median	1.860	1.760
Std Dev	0.250	0.273
n = 204		

Labs Eliminated: 147, 197, 218, 252, 275, 280, 296

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

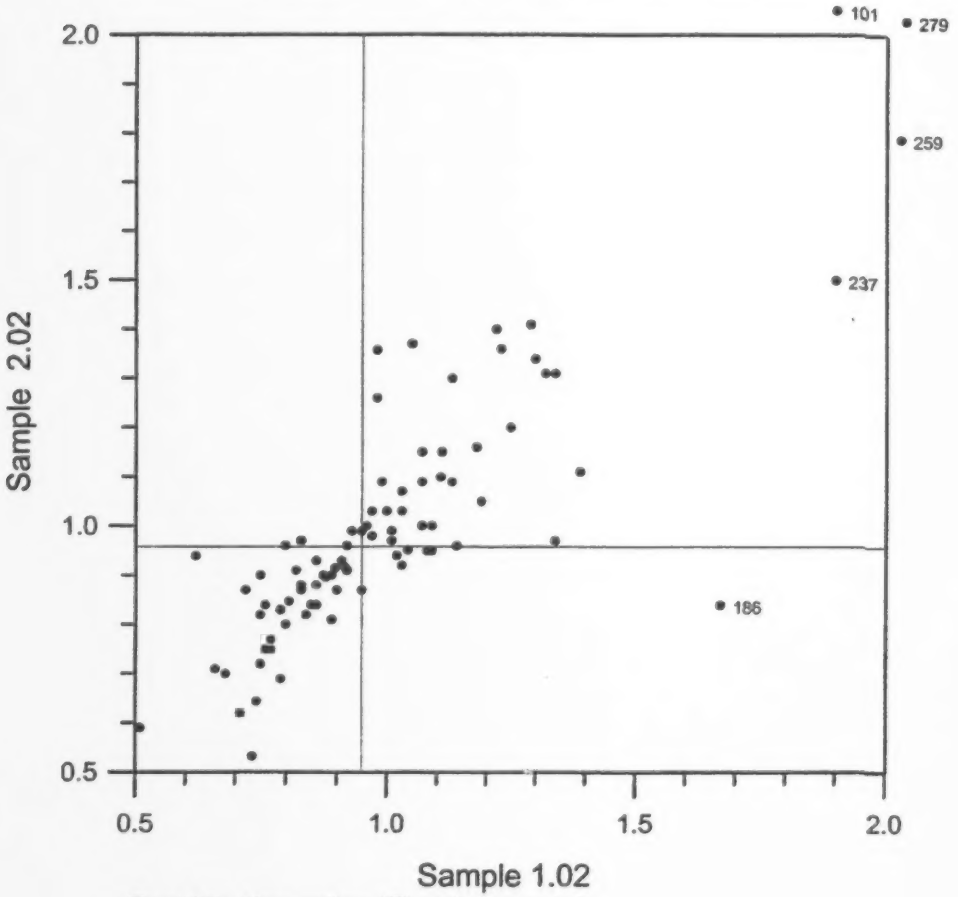


Test 27: Relative Density, (Fine Aggregate - Bulk)

	Mat 1	Mat 2
Mean	2.718	2.717
Median	2.717	2.717
Std Dev	0.015	0.013
n = 77		

Labs Eliminated: 64, 67, 101, 237, 259, 263, 264, 279, 280

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

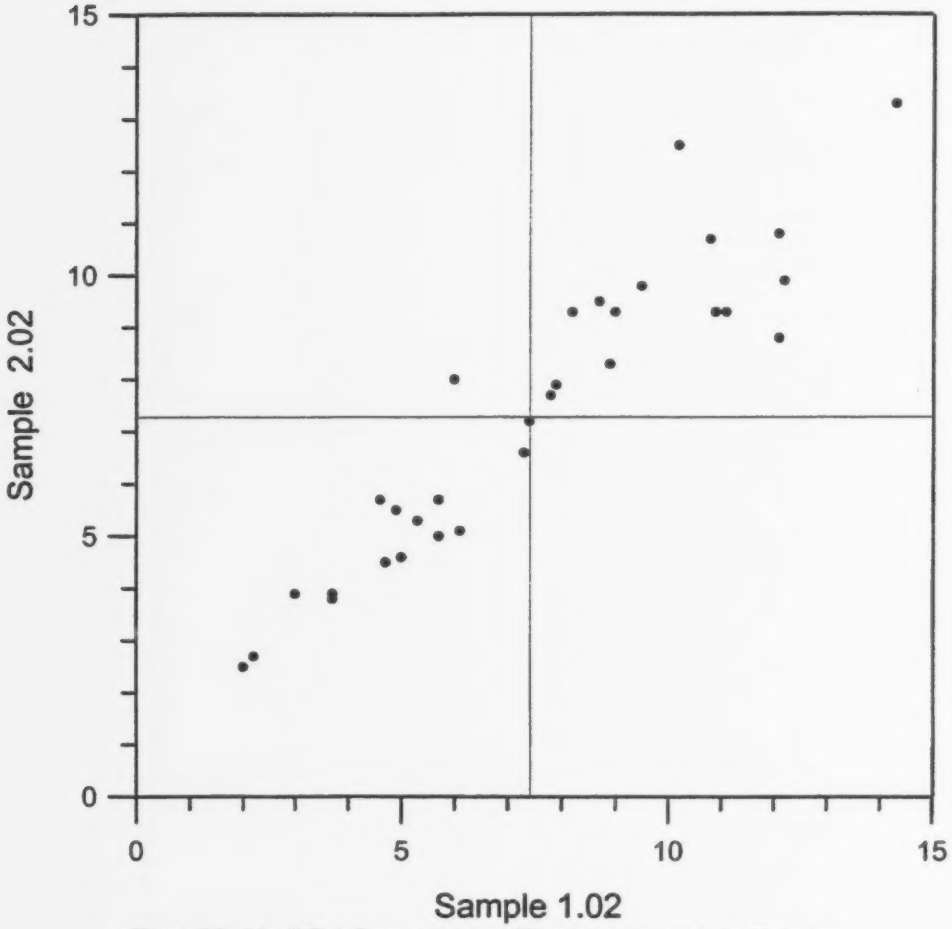


Test 28: Absorption (Fine Aggregate)

	Mat 1	Mat 2
Mean	0.955	0.968
Median	0.950	0.950
Std Dev	0.184	0.192
n = 81		

Labs Eliminated: 101, 186, 237, 259, 279

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

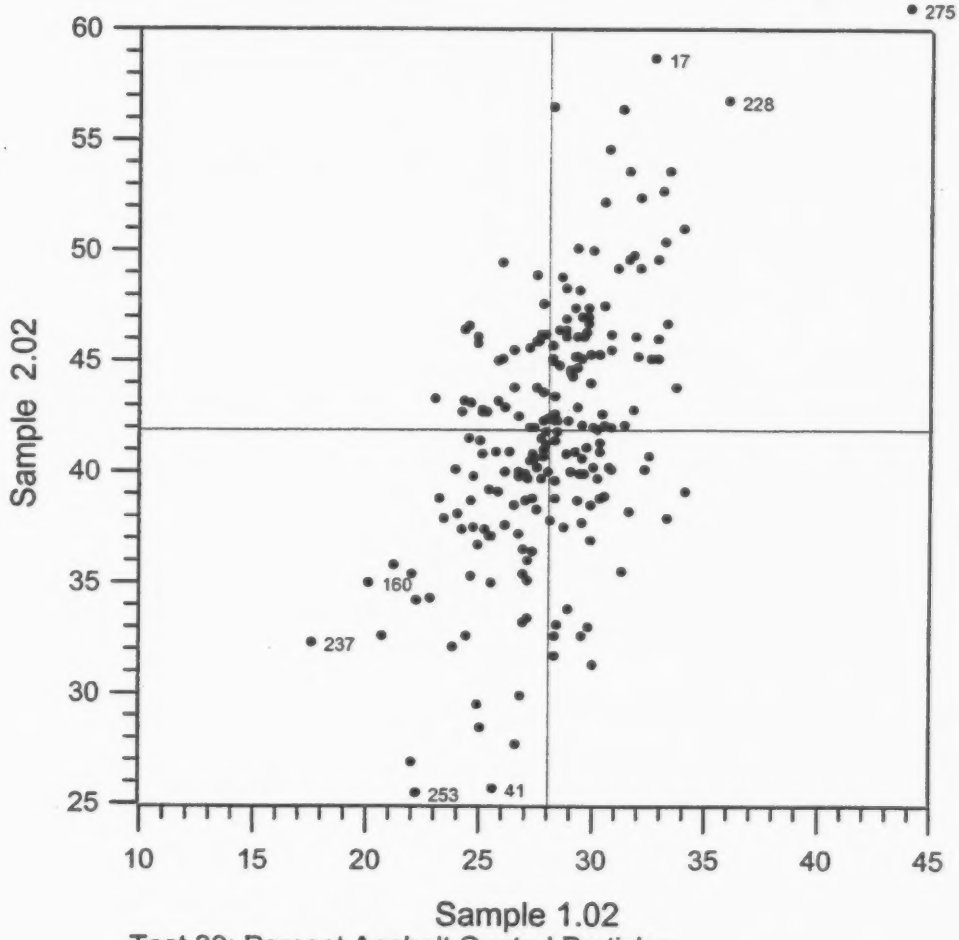


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	7.452	7.303
Median	7.400	7.700
Std Dev	3.245	2.844
n = 31		

Lab Eliminated: None

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

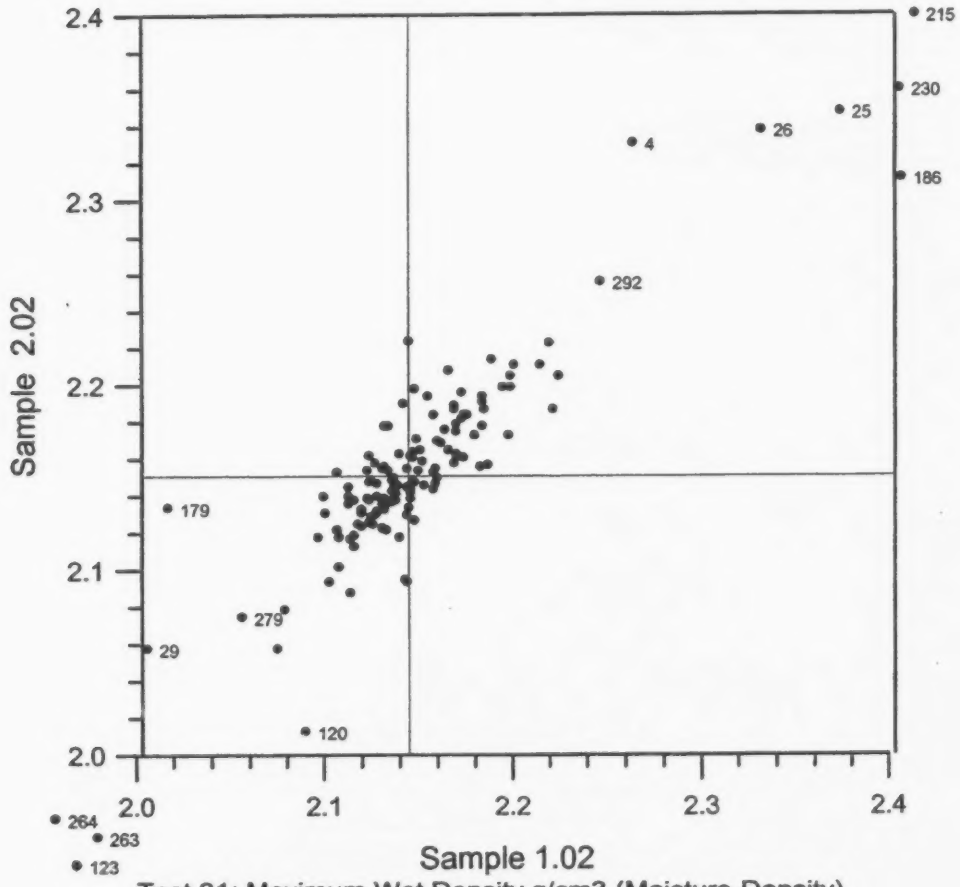


Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	28.151	41.850
Median	28.300	41.950
Std Dev	2.686	5.370
n = 202		

Labs Eliminated: 17, 41, 160, 228, 237, 253, 275

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

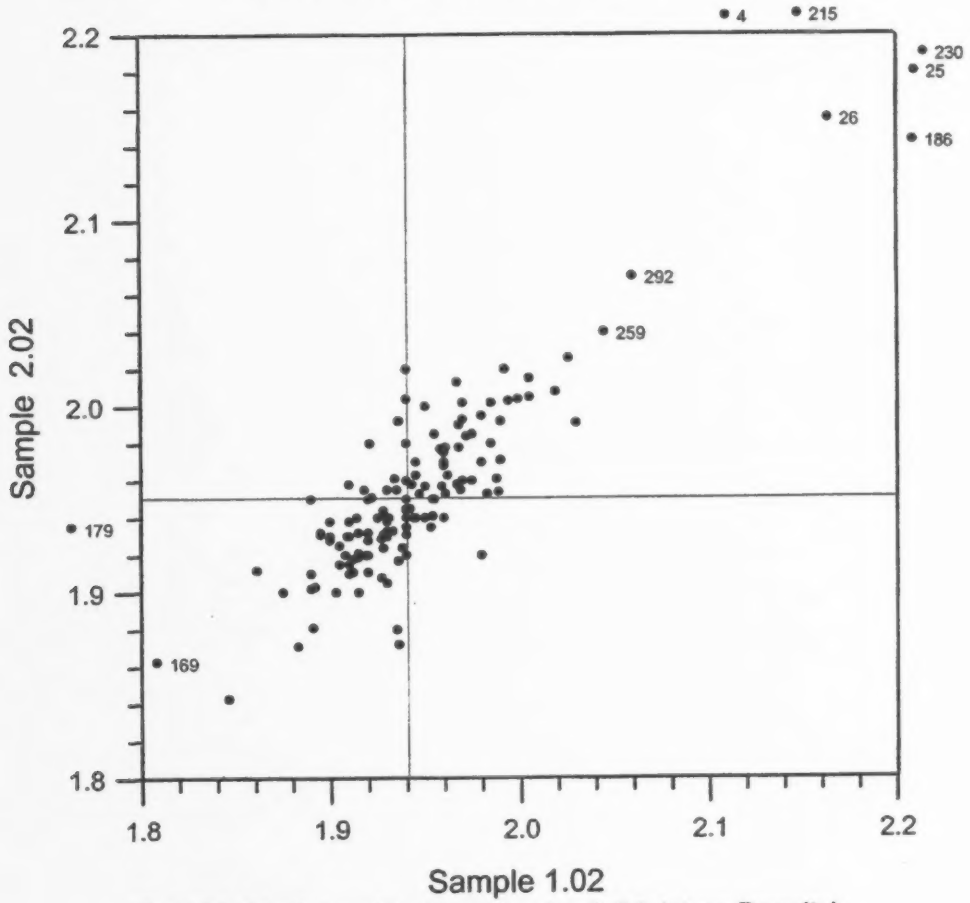


Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.146	2.153
Median	2.144	2.149
Std Dev	0.028	0.030
n = 130		

Labs Eliminated: 4, 25, 26, 29, 120, 123, 179, 186, 215, 230, 263, 264, 279, 292,

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

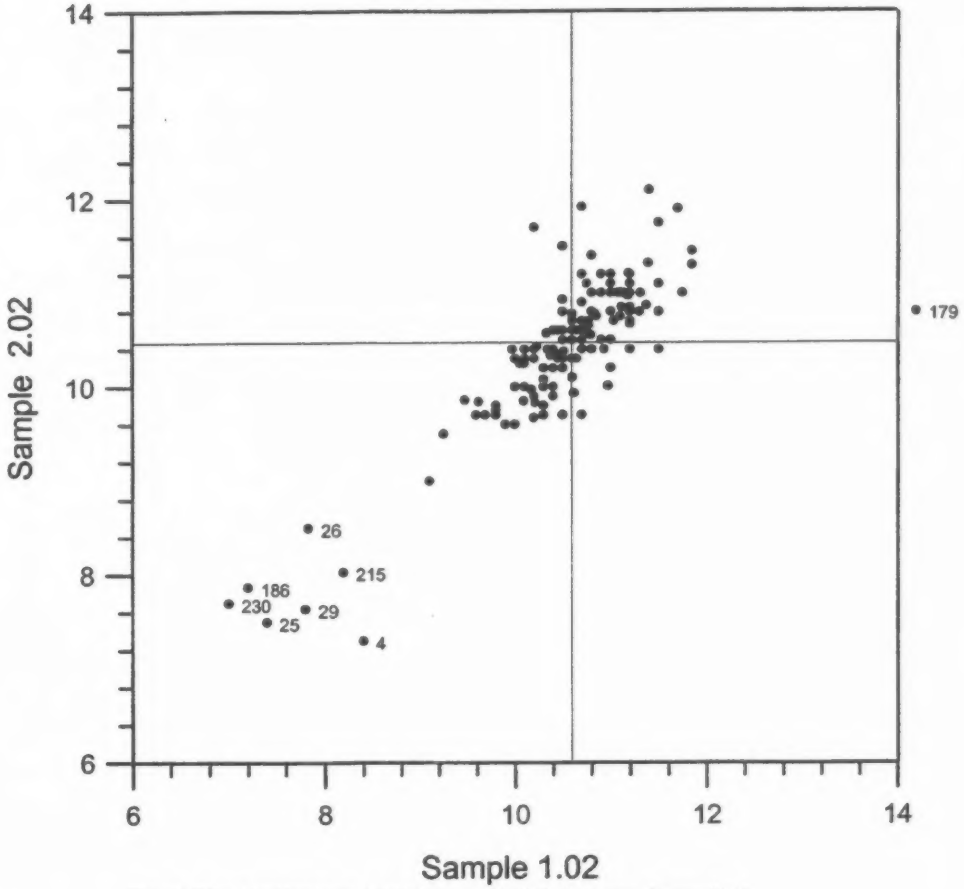


Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	1.941	1.949
Median	1.940	1.944
Std Dev	0.032	0.032
n = 133		

Labs Eliminated: 4, 25, 26, 123, 169, 179, 186, 215, 230, 259, 292

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

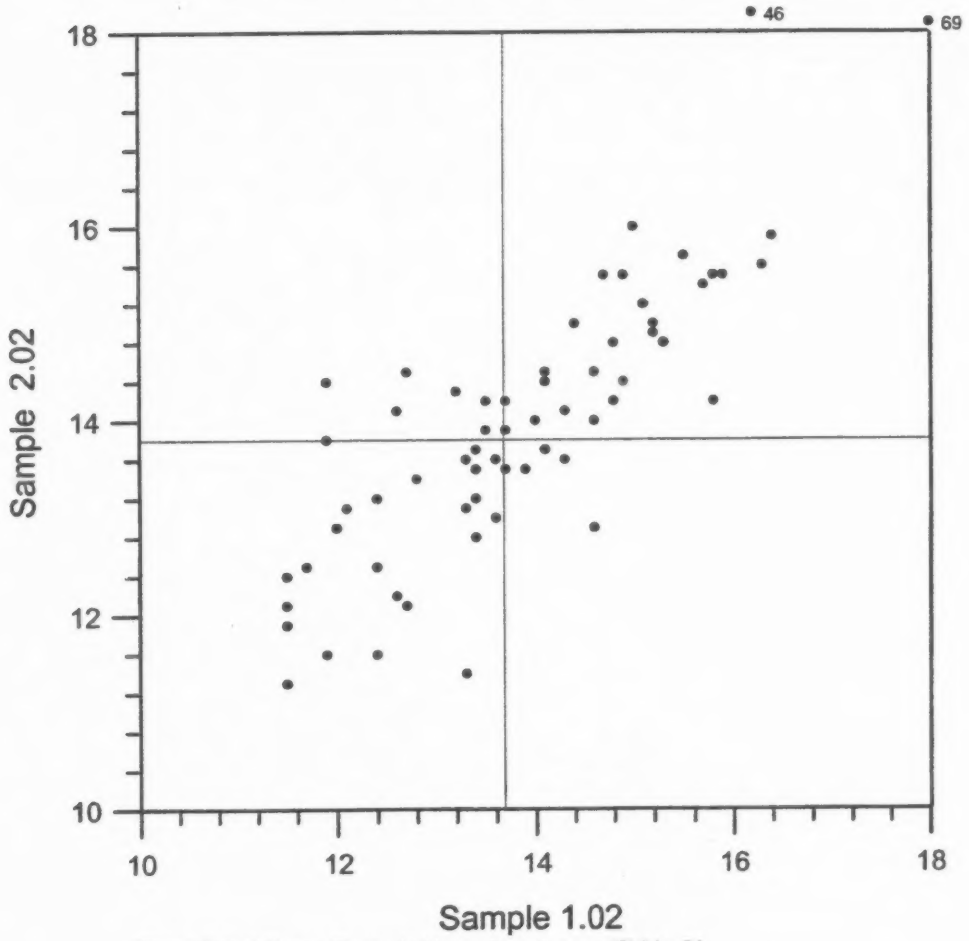


Test 33: Optimum Moisture, % (Moisture Density)

	Mat 1	Mat 2
Mean	10.635	10.533
Median	10.610	10.525
Std Dev	0.521	0.540
n = 136		

Labs Eliminated: 4, 25, 26, 29, 179, 186, 215, 230

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

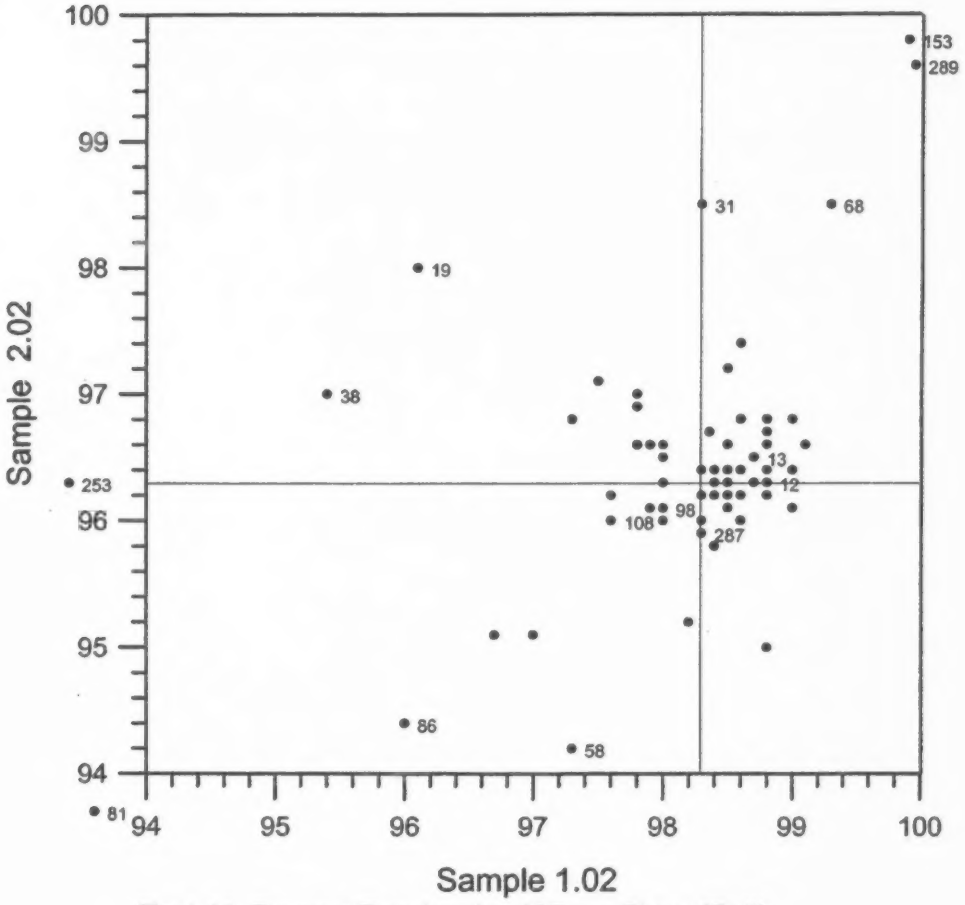


Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	13.744	13.833
Median	13.700	13.900
Std Dev	1.330	1.200
n = 62		

Labs eliminated: 46, 69

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

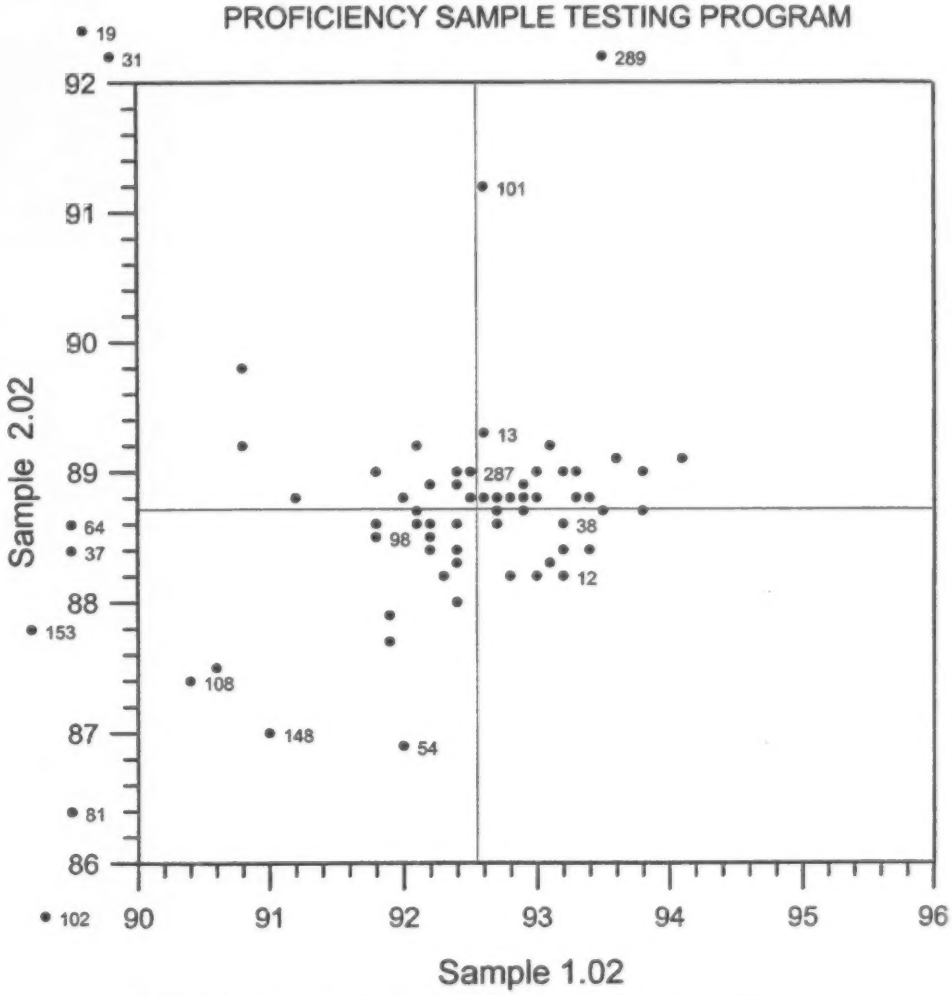


Test 41: Percent Passing the 425 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	98.349	96.339
Median	98.400	96.400
Std Dev	0.494	0.481
n = 60		

Labs eliminated: 12, 13, 19, 31, 38, 58, 68, 81, 86, 98, 108, 153, 253, 287, 289

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

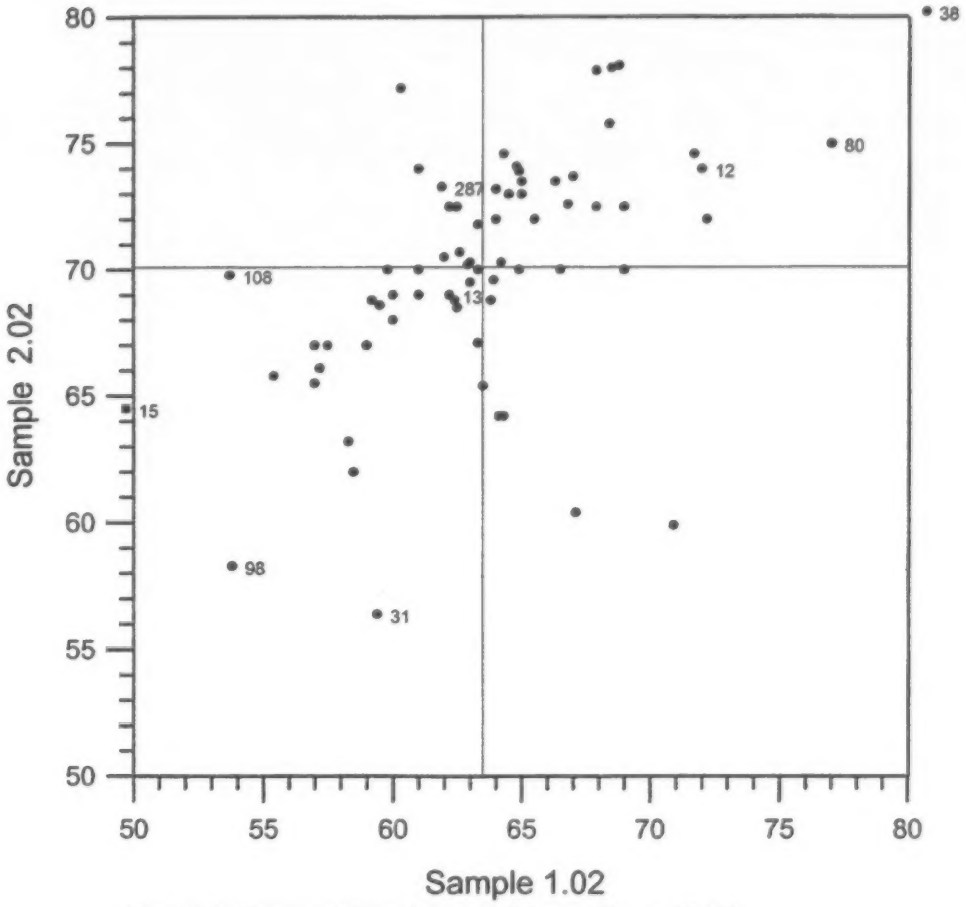


Test 42: Percent Passing the 75 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	92.552	88.665
Median	92.550	88.700
Std Dev	0.745	0.402
n = 58		

Labs eliminated: 12, 13, 19, 31, 37, 38, 54, 64, 81, 98, 101, 102, 108, 148, 153, 287, 289

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

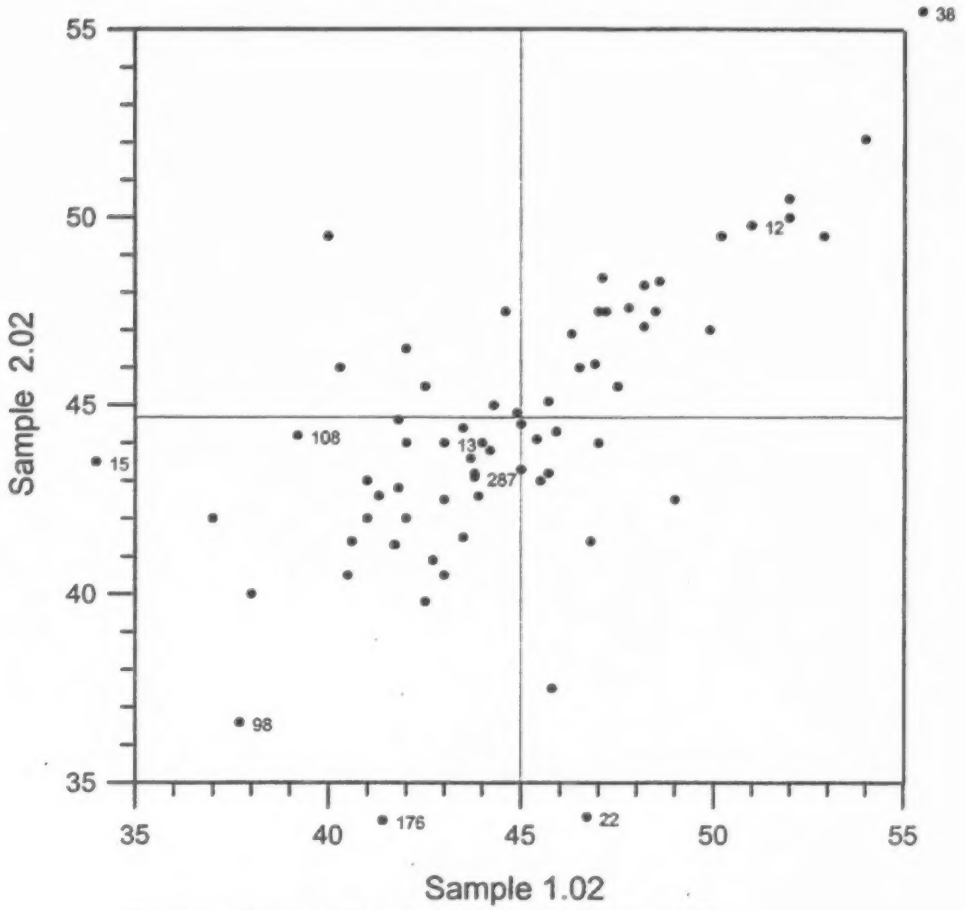


Test 43: Percent Passing the 20 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	63.557	70.232
Median	63.400	70.100
Std Dev	3.803	4.066
n = 66		

Labs eliminated: 12, 13, 15, 31, 38, 80, 98, 108, 287

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

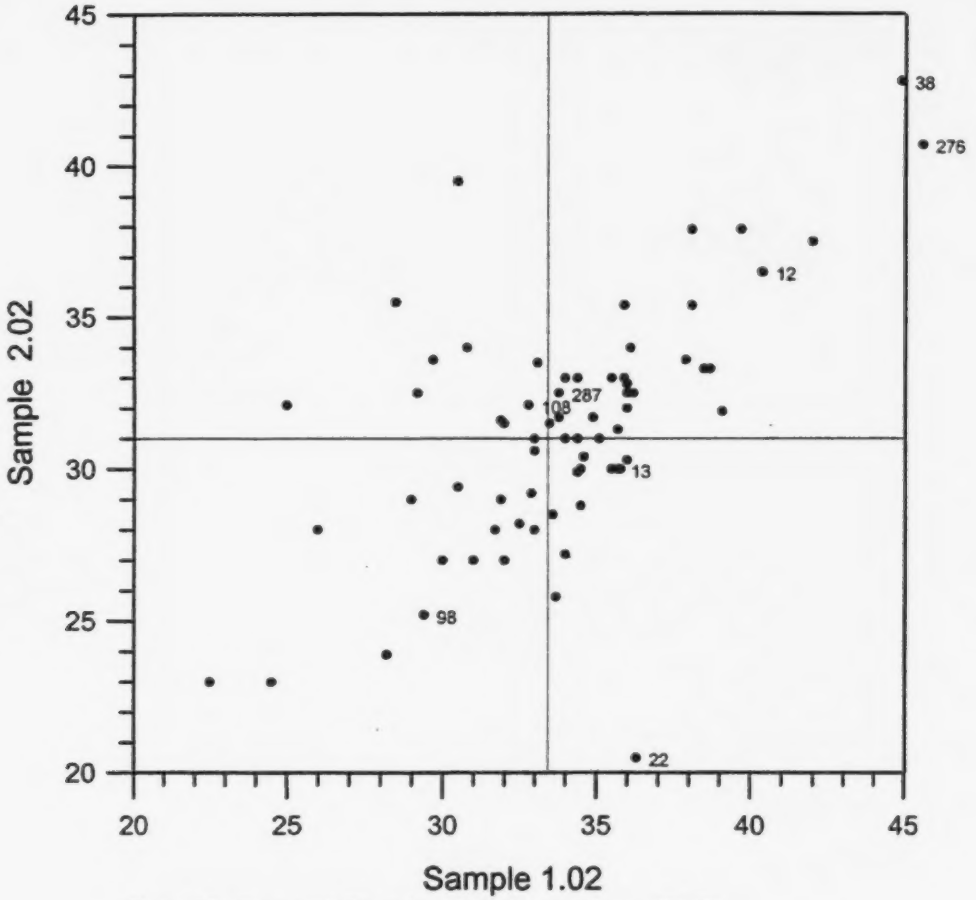


Test 44: Percent Passing the 5 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	44.995	44.723
Median	44.750	44.350
Std Dev	3.551	3.052
n = 66		

Labs eliminated: 12, 13, 15, 22, 38, 98, 108, 176, 287

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

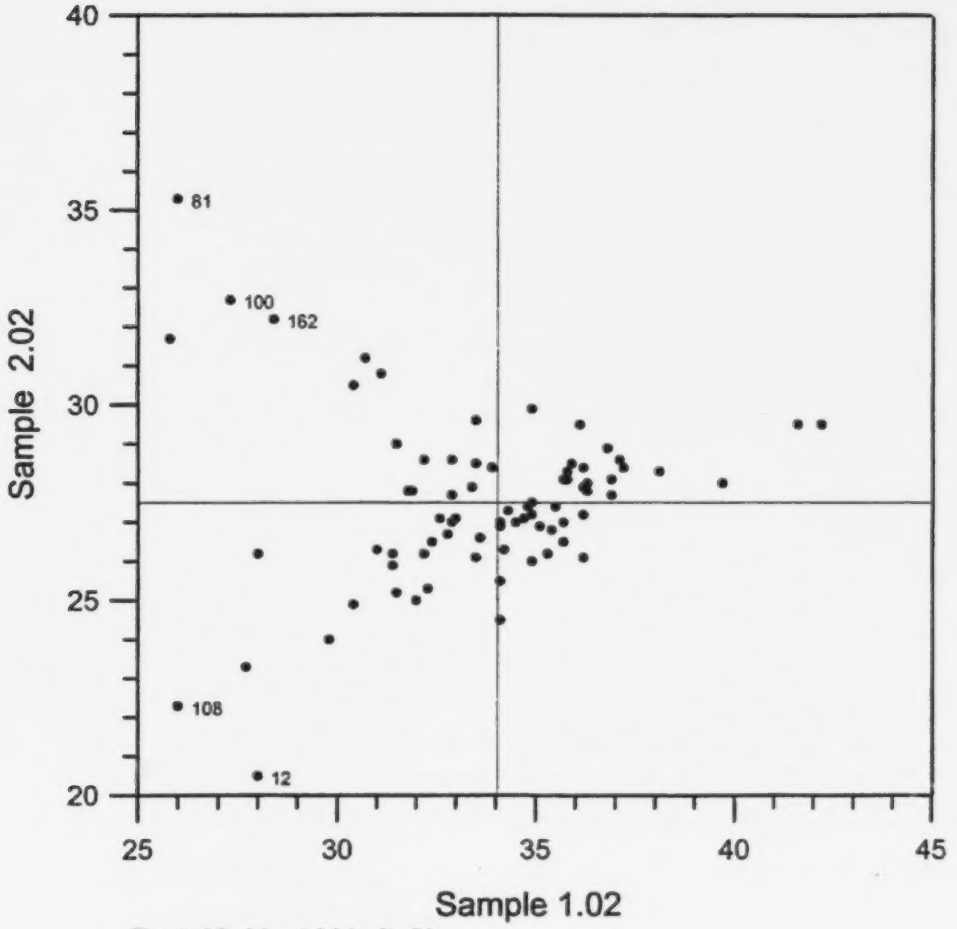


Test 45: Percent Passing the 2 µm Sieve (Soil)

	Mat 1	Mat 2
Mean	33.402	31.085
Median	34.000	31.500
Std Dev	3.766	3.377
n = 67		

Labs eliminated: 12, 13, 22, 38, 98, 108, 276, 287

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

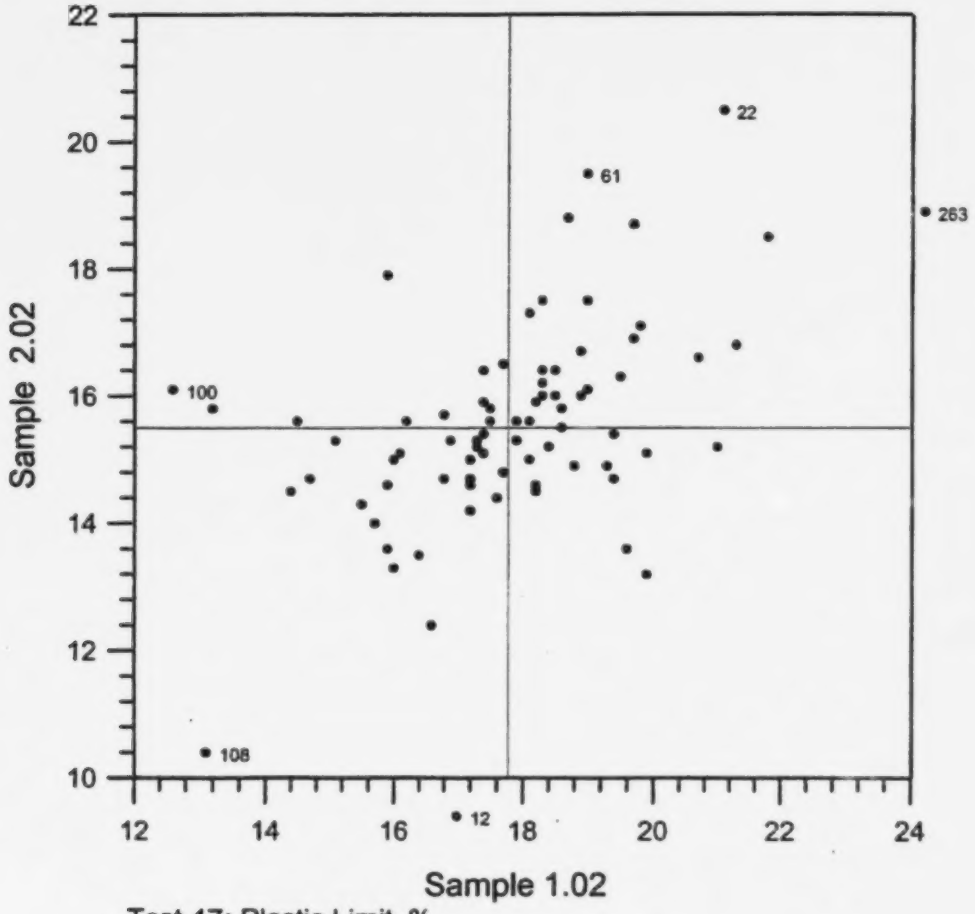


Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	34.105	27.459
Median	34.200	27.400
Std Dev	2.798	1.582
n = 73		

Labs eliminated: 12, 81, 100, 108, 162

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

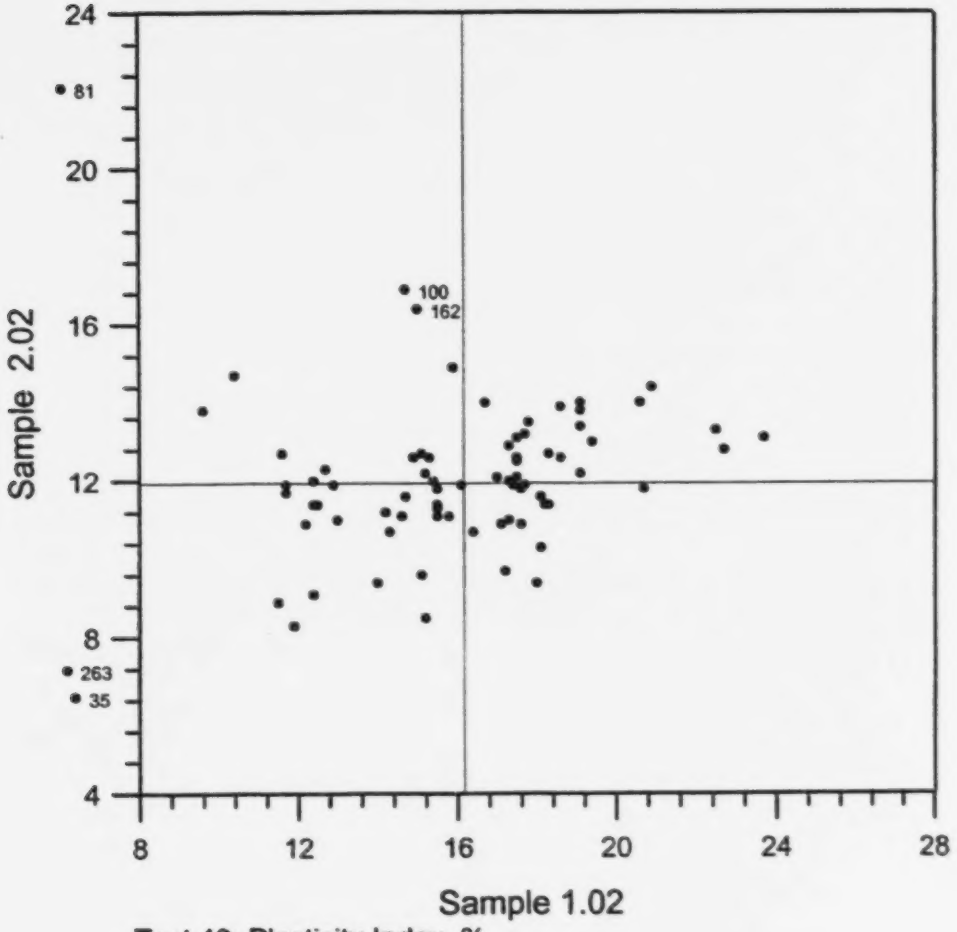


Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	17.818	15.522
Median	18.000	15.400
Std Dev	1.655	1.245
n = 72		

Labs eliminated: 12, 22, 61, 100, 108, 263

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM

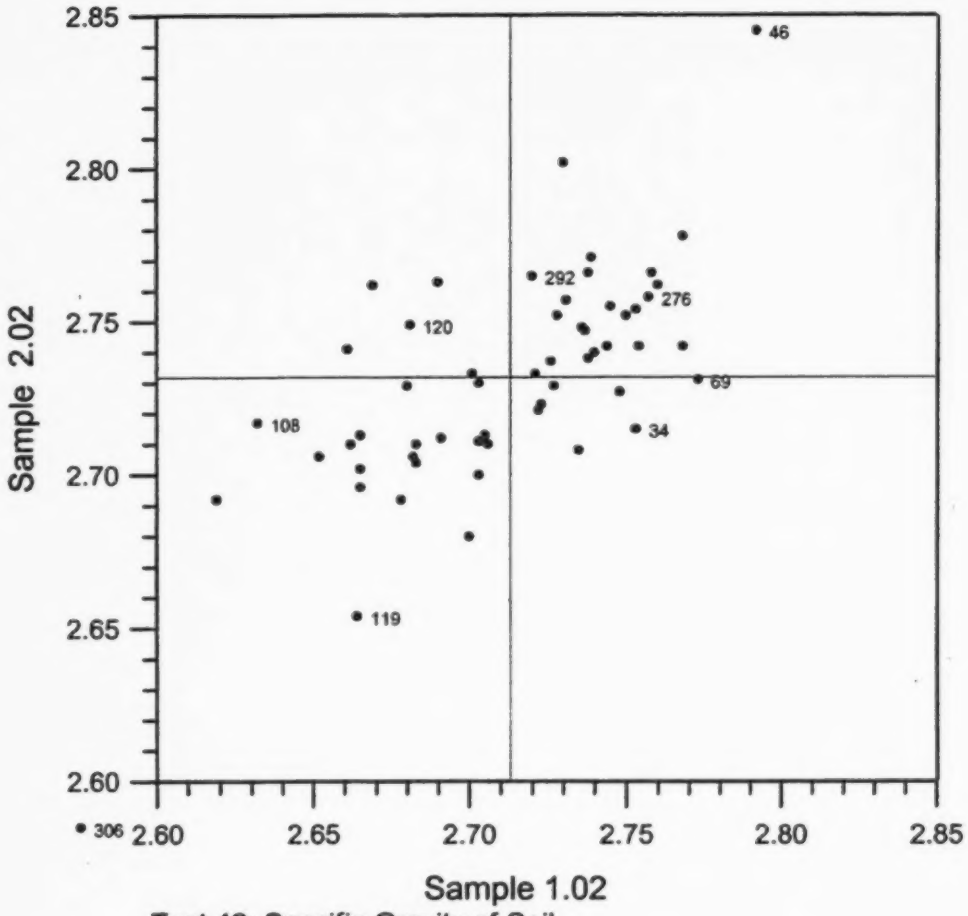


Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	16.227	11.910
Median	16.700	11.900
Std Dev	2.934	1.419
n = 73		

Labs eliminated: 35, 81, 100, 162, 263

2002 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 49: Specific Gravity of Soil

	Mat 1	Mat 2
Mean	2.713	2.732
Median	2.724	2.733
Std Dev	0.035	0.026
n = 56		

Labs eliminated: 34, 46, 69, 108, 119, 120, 276, 292, 306

Appendix E1: Results of Coarse Aggregate Petrographic Correlation

Laboratory Number	**13**	**13**	**15**	**15**	**19**	**19**	**23**	**23**	**28**	**28**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	81.3	74.6	31.1	33.4	0	0	35.3	39.2	54.4	63.1
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	10.1	17.2	59.2	56.3	0	0	33.1	38.6	35.3	28.9
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Carbonate (slightly cherty: <5% chert)	1.7	2.7	1.1	0	0	0	4.4	3.2	0	0
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	0	0	0	0	0	0	0
Quartzite	0	0	0	0	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	100	100	0	0	0	0
Gypsite (<10% gypsum)	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**93.1**	**94.5**	**91.4**	**89.7**	**100**	**100**	**72.8**	**81**	**89.7**	**92**
Carbonate (soft; silty, soft; slightly shaley)	6.6	3	8.6	9.7	0	0	17.1	11.3	9.2	7
Carbonate (soft, pitted)	0	0	0	0	0	0	0	0	1.1	0.4
Carbonate (deeply weath.; silty, deeply weath.)	0.2	0.6	0	0	0	0	6.3	5.1	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	2.7	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0.1	0	0	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Total Fair Aggregate (%)	**6.8**	**3.7**	**8.6**	**9.7**	**0**	**0**	**26.1**	**16.4**	**10.3**	**7.4**
Carbonate (shaley; clayey; silty, clayey)	0.1	1.8	0	0.4	0	0	1	2.2	0	0.6
Total Poor Aggregate (%)	**0.1**	**1.8**	**0**	**0.4**	**0**	**0**	**1**	**2.2**	**0**	**0.6**
Shale	0	0	0	0.2	0	0	0.1	0.4	0	0
Total Deleterious Aggregate (%)	**0**	**0**	**0**	**0.2**	**0**	**0**	**0.1**	**0.4**	**0**	**0**
Petrographic Number (Concrete)	**114**	**116**	**117**	**123**	**100**	**100**	**158**	**147**	**121**	**118**

Laboratory Number	**31**	**31**	**35**	**35**	**37**	**37**	**38**	**38**	**39**	**39**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	92.1	91.5	95.9	96.1	74.7	88.3	0	0	90.4	90.6
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	0	0	0	0	22.2	7.6	84.7	84	3.7	3.4
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Carbonate (slightly cherty: <5% chert)	0	0	0	0	0	0	0	0	0	0
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	1.6	0	0	0	0	0	0
Quartzite	0	0	0	0.2	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gypsite (<10% gypsum)	0	0	3.6	1.8	0	0	0	0	0	0
Total Good Aggregate (%)	**92.1**	**91.5**	**99.5**	**99.7**	**96.9**	**95.9**	**84.7**	**84**	**94.1**	**94**
Carbonate (soft; silty, soft; slightly shaley)	4.3	7.7	0	0	1.3	2.4	15.3	15.7	5.9	6
Carbonate (soft, pitted)	0	0	0	0	0.6	0.7	0	0	0	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	0	0	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	0	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	2.9	0.8	0.5	0.3	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Total Fair Aggregate (%)	**7.2**	**8.5**	**0.5**	**0.3**	**1.9**	**3.1**	**15.3**	**15.7**	**5.9**	**6**
Carbonate (shaley; clayey; silty, clayey)	0.7	0	0	0	1.2	1	0	0	0	0
Total Poor Aggregate (%)	**0.7**	**0**	**0**	**0**	**1.2**	**1**	**0**	**0**	**0**	**0**
Shale	0	0	0	0	0	0	0	0.3	0	0
Total Deleterious Aggregate (%)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.3**	**0**	**0**
Petrographic Number (Concrete)	**118**	**117**	**101**	**101**	**110**	**111**	**131**	**134**	**112**	**112**

Laboratory Number	**40**	**40**	**47**	**47**	**59**	**59**	**61**	**61**	**71**	**71**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	77.7	70.3	22.9	37.2	75.4	76.9	71.6	77.9	73.3	71.2
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	14.9	16.1	36.8	20.4	12.4	13.9	16.8	13.1	11.5	21.7
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0	0	0	13.9	6.4
Carbonate (slightly cherty; <5% chert)	0	0	11.8	12.9	1.7	1.9	0	0	0.9	0.4
Marble (hard or medium hard)	0	0	0	0	0	0.5	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	0	0	0	0	0	0	0
Quartzite	0	0	0	0	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gypsite (<10% gypsum)	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**92.6**	**86.4**	**71.5**	**70.5**	**89.5**	**93.2**	**88.4**	**91**	**99.6**	**99.7**
Carbonate (soft; silty, soft; slightly shaley)	7.4	12.8	20.1	24.5	9.8	6.5	8.6	7.8	0.1	0.3
Carbonate (soft, pitted)	0	0	0	0	0	0	0	0	0.2	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	0	0	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	0	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0	5.8	4.5	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0.1	0
Total Fair Aggregate (%)	**7.4**	**12.8**	**25.9**	**29**	**9.8**	**6.5**	**8.6**	**7.8**	**0.4**	**0.3**
Carbonate (shaley; clayey; silty, clayey)	0	0.8	1.8	0.3	0.7	0.3	2.8	1.1	0	0
Total Poor Aggregate (%)	**0**	**0.8**	**1.8**	**0.3**	**0.7**	**0.3**	**2.8**	**1.1**	**0**	**0**
Shale	0	0	0.8	0.2	0	0	0.2	0.1	0	0
Total Deleterious Aggregate (%)	**0**	**0**	**0.8**	**0.2**	**0**	**0**	**0.2**	**0.1**	**0**	**0**
Petrographic Number (Concrete)	**115**	**130**	**168**	**161**	**123**	**115**	**133**	**122**	**101**	**101**

Laboratory Number	**72**	**72**	**80**	**80**	**83**	**83**	**100**	**100**	**101**	**101**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	97.1	98	77.3	80.7	37	19.3	68.1	64.2	94.2	94.2
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	0.3	2	13.7	12.3	47.1	62.2	20.2	20.8	0	0
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0.1	0	0	0	0
Carbonate (slightly cherty: <5% chert)	2.6	0	1.5	0.7	0	0	0	0	0.6	0.3
Marble (hard or medium hard)	0	0	0.3	0	0	0	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	0	0	0	0	0	0	0
Quartzite	0	0	0	0	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gypsite (<10% gypsum)	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**100**	**100**	**92.8**	**93.7**	**84.1**	**81.6**	**88.3**	**85**	**94.8**	**94.5**
Carbonate (soft; silty, soft; slightly shaley)	0	0	6.6	6	15.5	18.4	10.5	15	3.1	4.1
Carbonate (soft, pitted)	0	0	0	0	0	0	0	0	0	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	0	0	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	0	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0	0	0.2	0	0	0	0	0.2	0.2
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Total Fair Aggregate (%)	**0**	**0**	**6.6**	**6.2**	**15.5**	**18.4**	**10.5**	**15**	**3.3**	**4.3**
Carbonate (shaley; clayey; silty, clayey)	0	0	0.3	0	0	0	1.2	0	1.6	1.2
Total Poor Aggregate (%)	**0**	**0**	**0.3**	**0**	**0**	**0**	**1.2**	**0**	**1.6**	**1.2**
Shale	0	0	0.3	0.1	0.4	0	0	0	0.3	0
Total Deleterious Aggregate (%)	**0**	**0**	**0.3**	**0.1**	**0.4**	**0**	**0**	**0**	**0.3**	**0**
Petrographic Number (Concrete)	**100**	**100**	**117**	**113**	**135**	**137**	**127**	**130**	**117**	**115**

Laboratory Number	**112**	**112**	**150**	**150**	**162**	**162**	**172**	**172**	**175**	**175**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	84.6	76.5	22.1	6.7	62.7	64.1	34.4	38.9	0	0
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	0	0	38.8	57	25	23.5	60.9	56.8	0	0
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Carbonate (slightly cherty: <5% chert)	0	0	6.8	2.4	0	0	0	0	0	0
Marble (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	0	0	0	0	0	0	0
Quartzite	0	0	0	0	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	100	100
Gypsite (<10% gypsum)	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**84.6**	**76.5**	**67.7**	**66.1**	**87.7**	**87.6**	**95.3**	**95.7**	**100**	**100**
Carbonate (soft; silty, soft; slightly shaley)	11.9	20	29.3	33.3	11.8	11.8	4.5	3.3	0	0
Carbonate (soft, pitted)	0	0	0	0	0	0	0	0	0	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	0	0	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0	0	0	0	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0	0	0	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Total Fair Aggregate (%)	**11.9**	**20**	**29.3**	**33.3**	**11.8**	**11.8**	**4.5**	**3.3**	**0**	**0**
Carbonate (shaley; clayey; silty, clayey)	2.7	2.4	3	0.6	0.4	0.4	0.2	0.9	0	0
Total Poor Aggregate (%)	**2.7**	**2.4**	**3**	**0.6**	**0.4**	**0.4**	**0.2**	**0.9**	**0**	**0**
Shale	0.8	1.1	0	0	0.1	0.2	0	0.1	0	0
Total Deleterious Aggregate (%)	**0.8**	**1.1**	**0**	**0**	**0.1**	**0.2**	**0**	**0.1**	**0**	**0**
Petrographic Number (Concrete)	**144**	**162**	**174**	**170**	**127**	**127**	**110**	**112**	**100**	**100**

Laboratory Number	**188**	**188**	**196**	**196**	**203**	**203**	**260**	**260**	**295**	**295**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Carbonate (hard; silty, hard)	52.3	53.4	77.3	82.4	95.4	96.3	10.7	15.3	0	0
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	23.5	23.8	14	12.5	0	0	77.4	75.1	96	95.5
Carbonate (sandy, hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Carbonate (slightly cherty: <5% chert)	0	0	1.6	1.5	0	0	0	0	0	0
Marble (hard or medium hard)	0	0	0.4	0.2	0	0	0	0	0	0
Gneiss-Amphibolite-Schist (hard)	0	0	0	0	0	0	0	0	0	0
Quartzite	0	0	0	0	0	0	0	0	0	0
Volcanic (hard or medium hard)	0	0	0	0	0	0	0	0	0	0
Gypsite (<10% gypsum)	0	0	0	0	0	0	0	0	0	0
Total Good Aggregate (%)	**75.8**	**77.2**	**93.3**	**96.6**	**95.4**	**96.3**	**88.1**	**90.4**	**96**	**95.5**
Carbonate (soft; silty, soft; slightly shaley)	20.8	19.7	6.3	2.3	3.5	2.5	11.9	9.6	1.8	2.6
Carbonate (soft, pitted)	0	0	0	0	0	0	0	0	1.8	0.5
Carbonate (deeply weath.; silty, deeply weath.)	0	0	0	0	0	0	0	0	0	0
Carbonate (sandy, soft)	0	0	0	0.4	0	0	0	0	0	0
Marble (brittle)	0	0	0	0	0	0	0	0	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0	0	0.4	0	0	0	0	0	0
Argillite (medium soft)	0	0	0	0	0	0	0	0	0	0
Total Fair Aggregate (%)	**20.8**	**19.7**	**6.3**	**3.1**	**3.5**	**2.5**	**11.9**	**9.6**	**3.6**	**3.1**
Carbonate (shaley; clayey; silty, clayey)	3.4	3.1	0.2	0.3	1.1	1.2	0	0	0.3	1.2
Total Poor Aggregate (%)	**3.4**	**3.1**	**0.2**	**0.3**	**1.1**	**1.2**	**0**	**0**	**0.3**	**1.2**
Shale	0	0	0.2	0	0	0	0	0	0.1	0.2
Total Deleterious Aggregate (%)	**0**	**0**	**0.2**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0.2**
Petrographic Number (Concrete)	**159**	**155**	**115**	**108**	**112**	**111**	**124**	**119**	**110**	**114**

Laboratory Number	**301**	**301**
Sample Number	**1**	**2**
Carbonate (hard; silty, hard)	20.1	14.4
Carbonate ((silty,) surf. weath.; (silty,) med. hard)	73.1	77.8
Carbonate (sandy, hard or medium hard)	0	0
Carbonate (slightly cherty: <5% chert)	0	0
Marble (hard or medium hard)	0	0
Gneiss-Amphibolite-Schist (hard)	0	0
Quartzite	0	0
Volcanic (hard or medium hard)	0	0
Gypsite (<10% gypsum)	0	0
Total Good Aggregate (%)	**93.2**	**92.2**
Carbonate (soft; silty, soft; slightly shaley)	6.8	7.8
Carbonate (soft, pitted)	0	0
Carbonate (deeply weath.; silty, deeply weath.)	0	0
Carbonate (sandy, soft)	0	0
Marble (brittle)	0	0
Chert-Cherty Carbonate (<20% leached chert)	0	0
Argillite (medium soft)	0	0
Total Fair Aggregate (%)	**6.8**	**7.8**
Carbonate (shaley; clayey; silty, clayey)	0	0
Total Poor Aggregate (%)	**0**	**0**
Shale	0	0
Total Deleterious Aggregate (%)	**0**	**0**
Petrographic Number (Concrete)	**114**	**116**

Appendix E2: Results of Fine Aggregate Petrographic Correlation

Laboratory Number	35	35	37	37	47	47	59	59	80	80	101	101
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
Silicate (4.75-2.36 mm)	71.2	75	26.6	24.4	26	14.5	17.7	28.2	4.7	15.1	15.5	20.4
Silicate (2.36-1.18 mm)	85.8	77.1	38.5	29.9	18	10	18	17	16.2	16.9	11.8	14.3
Silicate (1.18-0.600 mm)	89.8	77.2	48.5	46.5	32.5	31.5	21.5	23	22.5	26.2	26.7	26.8
Silicate (0.600-0.300 mm)	77.1	82.7	77.9	63.7	53.5	48.5	47	55.5	54.2	46.6	54.9	50.5
Silicate (0.300-0.150 mm)	87.9	88.2	82.1	72	64.5	61	70.5	67	67.4	73.1	65.1	65.3
Silicate (0.150-0.075 mm)	78.4	82.5	76	66	68	64.5	71	70	78.7	75.2	74.4	72.8
Silicate (average) (%)	**81.7**	**80.4**	**58.3**	**50.4**	**43.7**	**38.3**	**40.9**	**43.4**	**40.6**	**42.2**	**41.4**	**41.7**
Carbonate (4.75-2.36 mm)	27.2	22	72.4	75.6	9.5	14	27.4	22.5	22.8	28.6	23.3	20.4
Carbonate (2.36-1.18 mm)	13.7	21.2	59.5	67.2	14	14.5	17.5	19.5	19.9	24.4	24.1	25.2
Carbonate (1.18-0.600 mm)	10.2	21.4	50.5	50.5	22.5	19.5	30	32.5	29	31	39.1	32
Carbonate (0.600-0.300 mm)	22.1	15.1	21.1	33.8	24	15.5	30.5	31	26.4	35	30.5	27.7
Carbonate (0.300-0.150 mm)	8.2	6.8	17.4	27	23	27	23.5	28	28.4	19.9	27.5	26.6
Carbonate (0.150-0.075 mm)	11.5	6.5	24	31.5	19.5	20.5	26.5	25	20.4	18.3	21.4	19.4
Carbonate (average) (%)	**15.5**	**15.5**	**40.8**	**47.6**	**18.7**	**18.5**	**25.9**	**26.4**	**24.5**	**26.2**	**27.6**	**25.2**
Shale (4.75-2.36 mm)	0.8	0	0	0	60	62	52.4	46.5	70.1	51.3	56.9	52.7
Shale (2.36-1.18 mm)	0.5	0	0	0	58.5	72	58.5	56.5	58.8	53.5	61.8	56.7
Shale (1.18-0.600 mm)	0	0	0	0	40	46	42	38	42	37.6	31.1	38.3
Shale (0.600-0.300 mm)	0	0	0	0	20.5	32.5	18.5	13	17.2	15.5	13.3	19.9
Shale (0.300-0.150 mm)	0	0	0	0	6	8	5.5	4	4.2	7	6.9	7.2
Shale (0.150-0.075 mm)	0	0	0	0	2.5	4.5	0.5	1.5	0	6	3.3	7.3
Shale (average) (%)	**0.2**	**0**	**0**	**0**	**31.3**	**37.5**	**29.6**	**26.6**	**32**	**28.5**	**28.9**	**30.3**
Mica (4.75-2.36 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Mica (2.36-1.18 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Mica (1.18-0.600 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Mica (0.600-0.300 mm)	0.4	0.9	0	0	0	0	0	0	0	0	0	0
Mica (0.300-0.150 mm)	3.9	3.8	0	0	5	4	0.5	0	0	0	0	0.5
Mica (0.150-0.075 mm)	10.1	11	0	0	10	10.5	2	3.5	0.9	0	0.9	0.5
Mica (average) (%)	**2.4**	**2.6**	**0**	**0**	**2.5**	**2.4**	**0.4**	**0.6**	**0.2**	**0**	**0.2**	**0.2**
Chert (4.75-2.36 mm)	0	0.7	1	0	4.5	9.5	2.5	2.8	2.4	5	4.3	6.5
Chert (2.36-1.18 mm)	0	0.4	2	2.9	9.5	3.5	6	7	5.1	5.2	2.3	3.8
Chert (1.18-0.600 mm)	0	0	1	3	5	3	6.5	6.5	6.5	5.2	3.1	2.9
Chert (0.600-0.300 mm)	0	0	1	2.5	2	3.5	4	0.5	1.8	2.9	1.3	1.9
Chert (0.300-0.150 mm)	0	0	0.5	1	1.5	0	0	1	0	0	0.5	0.4
Chert (0.150-0.075 mm)	0	0	0	2.5	0	0	0	0	0	0.5	0	0
Chert (average) (%)	**0**	**0.2**	**0.9**	**2**	**3.8**	**3.3**	**3.2**	**3**	**2.6**	**2.1**	**1.9**	**2.6**
Contamination (4.75-2.36 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (2.36-1.18 mm)	0	0	0	0	0	0	0	0	0	0	0	0

Contamination (1.18-0.600 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.600-0.300 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.300-0.150 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (0.150-0.075 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Contamination (average) (%)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Cementation (4.75-2.36 mm)	0.8	2.3	0	0	0	0	0	0	0	0	0	0
Cementation (2.36-1.18 mm)	0	1.3	0	0	0	0	0	0	0	0	0	0
Cementation (1.18-0.600 mm)	0	1.4	0	0	0	0	0	0	0	0	0	0
Cementation (0.600-0.300 mm)	0.4	1.3	0	0	0	0	0	0	0.4	0	0	0
Cementation (0.300-0.150 mm)	0	1.2	0	0	0	0	0	0	0	0	0	0
Cementation (0.150-0.075 mm)	0	0	0	0	0	0	0	0	0	0	0	0
Cementation (average) (%)	**0.2**	**1.3**	**0**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0**	**0**	**0**

Laboratory Number	**150**	**150**	**188**	**188**	**203**	**203**
Sample Number	**1**	**2**	**1**	**2**	**1**	**2**
Silicate (4.75-2.36 mm)	16.1	18.4	28.2	22.7	20.2	17.3
Silicate (2.36-1.18 mm)	14.5	20.4	31	31.5	18.1	13.2
Silicate (1.18-0.600 mm)	30.4	27.6	44.5	45.5	32.3	29.4
Silicate (0.600-0.300 mm)	53.8	56.1	68.5	63.5	52.4	50
Silicate (0.300-0.150 mm)	67.8	63.4	75.5	81.5	67.3	66.8
Silicate (0.150-0.075 mm)	68.3	73.9	85	88.5	73.7	76.6
Silicate (average) (%)	**41.8**	**43.3**	**55.5**	**55.5**	**44**	**42.2**
Carbonate (4.75-2.36 mm)	27.4	25	20	20	22.6	29.1
Carbonate (2.36-1.18 mm)	22.1	20.7	20.5	15.5	25.8	27.8
Carbonate (1.18-0.600 mm)	27.6	25.3	17.5	23	32.2	35.5
Carbonate (0.600-0.300 mm)	25	25.8	12.5	14.5	30.8	30.9
Carbonate (0.300-0.150 mm)	20.4	27.8	9.5	10.5	27.9	22.9
Carbonate (0.150-0.075 mm)	23.1	18.4	6	5	19.6	18.6
Carbonate (average) (%)	**24.3**	**23.8**	**14.3**	**14.8**	**26.5**	**27.5**
Shale (4.75-2.36 mm)	50.8	51.5	49.1	51.8	54.8	48.8
Shale (2.36-1.18 mm)	57.4	53.7	44.5	48.5	52.9	56
Shale (1.18-0.600 mm)	38.8	43	35	28	31.8	32.7
Shale (0.600-0.300 mm)	19.6	17.3	17	19	14.9	16.9
Shale (0.300-0.150 mm)	11.8	7.9	13	5.5	4.8	9.4
Shale (0.150-0.075 mm)	8.2	6.3	7.5	4	4.8	2.4
Shale (average) (%)	**31.1**	**30**	**27.7**	**26.1**	**27.3**	**27.7**
Mica (4.75-2.36 mm)	0	0	0	0	0	0
Mica (2.36-1.18 mm)	0	0	0	0	0	0
Mica (1.18-0.600 mm)	0	0	0	0	0	0
Mica (0.600-0.300 mm)	0.4	0	0	0.5	0	0
Mica (0.300-0.150 mm)	0	0	1	1	0	0
Mica (0.150-0.075 mm)	0.4	1.4	1.5	2.5	1.4	2.4
Mica (average) (%)	**0.1**	**0.2**	**0.4**	**0.7**	**0.2**	**0.4**
Chert (4.75-2.36 mm)	5.7	5.1	2.7	5.5	2.4	4
Chert (2.36-1.18 mm)	6	5.2	4	4.5	3.2	3
Chert (1.18-0.600 mm)	3.2	4.1	3	3.5	3.7	2.4
Chert (0.600-0.300 mm)	1.2	0.8	2	2.5	1.9	2.2
Chert (0.300-0.150 mm)	0	0.9	1	1.5	0	0.9
Chert (0.150-0.075 mm)	0	0	0	0	0.5	0
Chert (average) (%)	**2.7**	**2.7**	**2.1**	**2.9**	**2**	**2.1**
Contamination (4.75-2.36 mm)	0	0	0	0	0	0
Contamination (2.36-1.18 mm)	0	0	0	0	0	0
Contamination (1.18-0.600 mm)	0	0	0	0	0	0
Contamination (0.600-0.300 mm)	0	0	0	0	0	0
Contamination (0.300-0.150 mm)	0	0	0	0	0	0
Contamination (0.150-0.075 mm)	0	0	0	0	0	0
Contamination (average) (%)	**0**	**0**	**0**	**0**	**0**	**0**

Cementation (4.75-2.36 mm)	0	0	0	0	0	0.8
Cementation (2.36-1.18 mm)	0	0	0	0	0	0
Cementation (1.18-0.600 mm)	0	0	0	0	0	0
Cementation (0.600-0.300 mm)	0	0	0	0	0	0
Cementation (0.300-0.150 mm)	0	0	0	0	0	0
Cementation (0.150-0.075 mm)	0	0	0	0	0	0
Cementation (average) (%)	**0**	**0**	**0**	**0**	**0**	**0.1**

Appendix F1: Production Laboratory Ratings 2002

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
3	10	26.5	10	7	8	88
10	9	27.8	10	10		95
12	7	29.2	10	10	9	93
13	9	26.2	10	10	10	93
15	10	28.1	10	10	9	96
16	10	27.3	8	9	10	92
17	7	23.7	10	3	8	74
18	10	25.6	10	10	8	91
19	10	29.5	0	7	10	81
20	2	28.6	10	8		81
21	10	24.8	10	10		91
22	9	24.3	10	10	10	90
23	10	27.0	7	10	9	90
25	9	21.8	7	10	0	68
26	8	22.4	10	5	10	79
28	10	29.5	9	5	1	78
30	10	27.5	0	10	1	69
31	10	29.2	6	8	8	87
32	10	27.5	10	10	10	96
33	8	29.5	10	5	10	89
34	9	23.5	9	10	0	74
35	8	28.9	10	10	8	93
37	10	25.4	10	10	8	91
38	10	27.8	10	7	9	91
39	10	25.1	10	9	10	92
41	10	25.4	10	5	10	86
43	9	26.7	8	9		88
44	9	28.4	8	10	0	79
45	6	28.9	0	9	10	77
46	10	25.9	8	9	10	90
47	9	27.0	10	10	10	94
54	7	26.5	10	10	10	91
55	10	30.0	3	10	9	89
56	10	28.9	10	9	8	94
58	5	25.6	4	10	6	72
59	9	28.9	10	10	10	97

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
61	9	27.5	10	10	9	94
64	10	29.5	10	9	10	98
66	10	27.5	10	9	0	81
67	10	28.9	10	6		92
68	10	28.6	10	9	9	95
69	8	27.8	10	5	5	80
71	6	27.5	10	8	8	85
72	5	26.5	10	9		84
79	10	22.6	10	10	9	88
80	6	22.4	10	4	10	75
81	7	28.1	9	10	8	89
83	10	27.5	10	9	0	81
85	10	30.0	10	10	9	99
86	10	30.0	9	6	10	93
90	6	28.9	10	8	10	90
94	10	28.4	10	10	10	98
98	10	24.8	9	10		90
100	10	28.4	10	10	10	98
101	10	26.7	10	8	8	90
102	10	26.5	0	8	10	78
103	10	27.0	10	9	10	94
104	10	28.1	10	9	2	84
105	10	24.5	5	10		83
107	10	30.0	0	10	7	81
108	10	29.2	10	10	10	99
110	9	29.2	10	10	10	97
112	8	29.5	10	10	10	96
113	10	27.0	8	10	10	93
114	10	25.4	4	9	6	78
115	10	27.3	10	10	10	96
116	7	28.1	10	10	8	90
117	9	27.5	0	10	10	81
118	10	25.6	10	9	10	92
120	10	28.1	10	10	8	94
123	10	27.3	10	10	9	95
124	8	29.5	10	10	9	95
126	10	27.0	9	9		92
127	1	24.5	10	9	10	78
128	10	27.0	10	10		95
129	9	25.9	10	10		92
132	2	25.4	3	10	10	72
134	7	27.0	9	10	10	90

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
136	0	18.8	5	9	10	61
137	9	26.7	10	10	9	92
138	10	25.6	10	10	10	94
139	2	29.5	7	6		74
141	10	24.3	10	6	10	86
142	10	29.2	10	9	10	97
144	4	28.4	10	10	0	75
145	8	28.6	9	8	10	91
146	10	28.6	5	10	9	89
147	10	3.5	10	9		54
148	8	25.9	0	8	10	74
149	10	25.6	5	6	9	79
153	9	26.7	10	8	6	85
156	8	25.1	10	6	10	84
157	9	28.6	10	8	10	94
158	7	24.3	10	10	10	88
160	8	27.0	10	4	10	84
161	9	29.7	10	10		98
162	10	28.1	10	10	10	97
163	10	21.0	10	8		82
164	8	27.8	10	10	9	93
167	7	29.7	10	9	10	94
169	8	27.0	0	10	3	69
171	10	29.5	7	10		94
172	10	29.2	7	10	10	95
175	10	26.7	10	7	10	91
177	10	23.7	10	10	10	91
178	10	29.7	10	10	1	87
179	10	27.0	5	7	7	80
180	10	25.1	5	10	9	84
181	8	24.5	10	10	4	81
182	9	22.9	9	9	0	71
184	5	26.7	9	10	7	82
186	4	20.2	10	6	9	70
187	10	28.4	6	10	10	92
188	10	26.5	9	10	10	94
189	6	21.0	10	9	8	77
191	9	25.4	8	10	10	89
193	10	27.8	9	10	10	95
194	10	27.0	10	9	10	94
197	8	17.7	10	8		73
198	10	22.9	9	7	1	71

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
199	10	28.9	10	10	7	94
200	10	29.2	5	10	9	90
201	10	28.9	10	8		95
202	10	28.6	9	10		96
204	9	29.7	9	6	8	88
205	10	24.3	9	8	10	88
208	8	29.2	10	10	3	86
209	10	26.5	10	8	6	86
212	8	17.5	9	9	0	62
214	10	25.9	8	8	8	86
215	0	27.5	10	9	9	79
216	10	27.8	10	10	10	97
217	9	27.8	7	10		90
218	8	12.8	9	6	0	51
219	4	27.8	9	6	10	81
221	10	28.6	10	10	8	95
223	9	28.6	8	10		93
224	5	12.5	9	10	10	66
228	9	26.7	1	1	1	55
230	10	27.0	10	8	10	93
232	10	26.7	7	10	9	90
233	10	24.5	10	7		86
234	10	28.9	10	9	8	94
235	10	22.1	10	9	10	87
236	7	28.6	2	10	10	82
237	10	12.8	9	3	10	64
242	10	26.2	10	10		94
244	10	28.9	10	9		97
245	8	28.6	10	10	9	94
246	9	29.7	8	10	10	95
247	8	29.5	9	3		82
248	9	24.8	7	8		81
249	10	27.8	7	10	10	93
250	9	27.8	10	9	10	94
251	9	21.3	9	10	10	85
252	0	19.4	7	10		61
253	9	27.8	6	2	10	78
254	3	29.7	7	10	10	85
255	10	25.1	10	10		92
256	9	26.2	10	9	8	89
257	5	25.4	5	9		74
258	7	27.5	10	9	10	91

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
259	10	27.0	9	10	9	93
260	9	26.2	10	10	10	93
262	0	28.6	0	8	6	61
263	9	20.5	0	8	10	68
264	10	28.9	0	10	8	81
269	8	25.1	9	8		83
271	10	28.6	10	10	10	98
272	10	24.3	10	10	10	92
273	10	27.8	9	10	1	83
274	10	26.2	10	10	10	95
275	10	27.3	10	0	10	82
276	10	29.5	9	10	10	98
277	10	19.6	6	10		76
278	0	28.6	10	10	8	81
279	9	26.5	10	8	10	91
280	8	12.8	0	10	10	58
281	10	29.2	9	10		97
284	10	25.1	0	10		75
285	10	24.8	7	10	8	85
287	10	21.0	10	9		83
288	9	22.9	5	10	8	78
289	9	27.3	10	8		90
290	9	29.2	8	10	4	86
291	6	26.5	8	10	9	85
292	10	28.1	6	9	10	90
293	7	29.5	9	10		92
294	7	27.5	8	10		88
295	9	29.5	10	10	10	98
297	10	29.7	9	8	10	95
298	7	21.8	0	9		63
299	8	28.6	10	10	9	94
300	10	27.8	0	10	10	83
301	10	22.4	10	10	10	89
302	6	25.1	0	8	9	69
303	5	29.5	1	9		74
305	10	24.5	10	10	9	91
306	0	25.6	9	10	9	77
309	5	21.0	9	9	10	77
310	10	29.2	10	10		99
311	10	25.1	10	8		88
312	6	28.6	8	8	9	85
313	7	27.3	7	7		80

Appendix F2: Full Service Aggregate Laboratory Ratings 2002

FULL SERVICE AGGREGATE LABORATORY RATINGS 2002

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
13	9	26.2		10	10	10	10	10	10	10	9.5	10	9.7	10	96
15	10	28.1		10	10	10	10	9	10	10	10	8	10.0	9	96
18	10	25.6		10	10	10	10	8	7	10	10	10	10.0	10	94
19	10	28.6	10	5		0	7	10	10	10	10		10.0	10	86
22	9	24.3		10		10	10	10	10	10	10		9.0	10	94
23	10	27.0		10	4	7	10	9	10	6	10	4	9.7	10	84
28	10	29.5		9.5		9	5	1	9	10	10		10.0	8	85
31	10	29.2	10	10	10	6	8	8	5	10	10	10	10.0	8	90
35	8	28.9	7	9	9	10	10	8	10	10	9.5	10	8.3	10	92
37	10	25.4	10	9.5	10	10	10	8	10	10	10	9	10.0	7	93
38	10	27.8	3	8	10	10	7	9	10	9	10	9	10.0	10	89
46	10	25.9		8.5	10	8	9	10	0	5	7.5	10	8.3	3	77
47	9	27.0	9	10		10	10	10	10	10	10		8.7	8	94
56	10	28.9	9	8.5	9	10	9	8	9	0	10	10	10.0	10	88
59	9	28.9		9	10	10	10	10	10	7	8	10	9.0	10	94
61	9	27.5		10	6	10	10	9	7	10	8	10	10.0	10	91
69	8	27.8		10		10	5	5	9	10	4.5		10.0	1	77
79	10	22.6		7.5		10	10	9	10	10	9		9.3	10	90
80	6	22.4	10	6	9	10	4	10	10	10	10	10	8.7	9	84
83	10	27.5		10		10	9	0	10	9	10		10.0	6	86
86	10	30.0		7.5		9	6	10	10	10	10		9.0	10	93
90	6	28.9		10		10	8	10	10	10	10			9	93
100	10	28.4		10	10	10	10	10	10	8	7			10	95

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-606 $MgSO_4$ (FA)	LS-623 One Point Proctor	LS-619 MDA (FA)	Rating
101	10	26.7	10	9.5	6	10	8	8	10	10	0.5	10	10.0	9	86
107	10	30.0		8.5	10	0	10	7	10	10	10	8		9	88
110	9	29.2		10		10	10	10	9	10	8.5			10	96
112	8	29.5		10	9	10	10	10	8	7	8.5	10	10.0	10	93
123	10	27.3		9.5	4	10	10	9	4	5	7	9	3.3	10	79
124	8	29.5		10		10	10	9	8	10	10		10.0	9	95
157	9	28.6		9	10	10	8	10	10	10	10	8		10	95
162	10	28.1		10	10	10	10	10	9	10	8			10	96
164	8	27.8		6.5		10	10	9	10	6	10			10	89
172	10	29.2		9	7	7	10	10	10	8	10	10	10.0	8	92
188	10	26.5	9	8.5	10	9	10	10	10	10	9	10	10.0	10	95
205	10	24.3		6.5		9	8	10	9	10	7		10.0	10	88
214	10	25.9		10	10	8	8	8	9	10	10			10	91
216	10	27.8		9		10	10	10	7	10	8	10	9.7	10	94
245	8	28.6		8		10	9	10	10	8	9		10.0	10	93
253	9	27.8		10		6	2	10	8	0	9.5		5.3	8	74
260	9	26.2		10	10	10	10	10	10	9	8.5	8	8.7	7	91
263	9	20.5		5	10	0	8	10	10	10	3.5	6	6.3	7	70
285	10	24.8		9.5	9	7	10	8	10	10	10		9.0	10	91
295	9	29.5		7.5	10	10	10	10	10	10	9.5	10	10.0	9	96
301	10	22.4		9.5	10	10	10	10	6	10	10	10	9.3	8	90
306	0	25.6		9.5	10	9	10	9	10	10	10	6	10.0	10	86

Appendix F3: Soil Laboratory Ratings 2002

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
15	6.6	10.0	8	82
18	10.0	10.0	10	100
19	5.2	10.0	10	84
22	5.4	6.3	10	72
28	9.0	8.0	10	90
29	9.6	7.3	8	83
30	9.0	10.0	9	93
31	5.2	9.0	10	81
32	9.2	9.7	4	76
34	9.6	5.3	0	50
35	9.6	4.0	9	75
37	8.6	10.0	10	95
38	0.0	8.7	8	56
44	9.4	9.7	10	97
46	9.2	9.7	0	63
47	9.4	9.3	9	92
54	7.4	10.0	8	85
56	10.0	8.3	6	81
58	8.4	10.0	10	95
59	10.0	9.0	10	97
64	8.4	7.3	8	79
66	7.2	7.3	9	78
67	9.8	7.0	10	89
68	7.6	8.0	10	85
69	10.0	10.0	0	67
71	9.4	10.0	9	95
72	10.0	10.0	10	100
79	7.8	9.7	10	92
80	8.4	10.0	10	95
83	7.6	9.0	10	89
86	6.8	9.7	10	88
94	10.0	10.0	10	100
101	6.6	10.0	8	82
102	4.0	9.0	8	70
105	9.0	9.7	6	82
108	0.0	4.0	0	13
112	8.8	10.0	10	96
119	9.4	9.3	4	76
120	9.8	9.3	0	64
138	10.0	10.0	9	97
146	10.0	9.3	10	98
172	10.0	9.3	9	94
188	10.0	7.0	9	87
208	9.0	10.0	9	93
216	9.6	10.0	10	99
253	8.2	9.7	8	86
260	10.0	10.0	9	97
276	6.2	8.7	0	50
284	9.8	10.0	8	93
289	6.2	10.0	10	87
292	10.0	9.0	0	63
299	8.2	10.0	10	94
300	8.8	9.7	9	92
301	9.2	10.0	9	94
306	9.2	7.3	0	55